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THE SCIENTIFIC MONTHLY

VOL. 79 AUGUST 1954 NO. 2

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Science and Technology

(From the month's news releases; publication here does not constitute endorsement.)

Device Changes Tap Water into Distilled Water

A new device for rapidly changing ordinary tap water into the chemical equivalent of triple distilled water (in terms of specific resistance) for as little as 10 ct a gallon is comprised of a 16-oz polyethylene squeeze bottle, the bottom of which contains a mixture of cation and anion exchange resins. Tap water poured into the bottle comes into immediate contact with the resins and is converted to distilled water in about 1 min. (Central Scientific Co., Dept. SM, 1700 W. Irving Park Rd., Chicago, Ill.)

Utility Cart

An all-purpose device for suburban living, this utility cart has a removable canvas bag which is useful while gathering laundry, dead leaves, or trash. With the bag removed, the cart becomes a hand truck, weighing only 25 lb but capable of hauling 200-lb sacks or cans. Its framework can be collapsed for storage. (Canvas and Metal Specialties, Inc., Dept. SM, Groveville, N. J.)

Drop Counter

A new drop counter (Fig. 1), with a photoelectric cell connected to a timer, accurately counts drops from 1 to 400 at each setting. Drops fall directly from glass tip into collecting tube without touching any part of the counter assembly. The timer automatically indexes the collector to the next position after the set number of drops has been delivered into the tube. Ion-exchange or chromatographic columns may be used by employing stopcock to control flow rate. (Microchemical Specialties Co., Dept. SM, 1834 University Ave., Berkeley 3, Calif.)

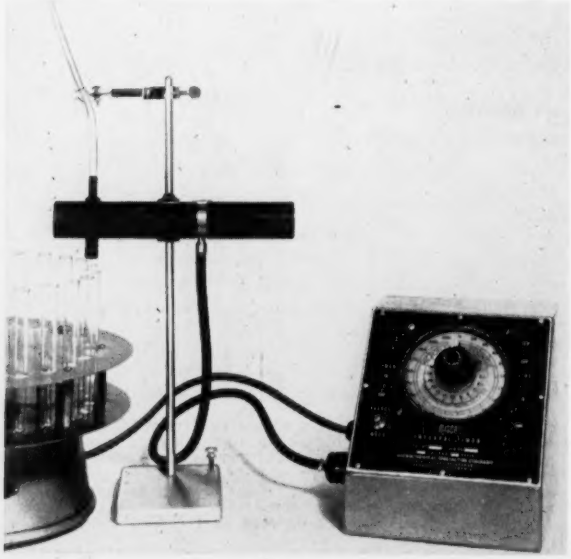

Fig. 1

Potassium Laboratory Arc

A new potassium laboratory arc furnishes monochromatic radiation of potassium for polarimetry, interferometry, refractometry, and spectrometry, and is suitable for general work in chemical and physical laboratories. Strong red-line radiation can be obtained with approximately 97 percent of energy radiated in the region of 7699 to 7765 A. Other line radiations can easily be removed by filtering. (George W. Gates & Co., Inc., Dept. SM, Hempstead Turnpike & Lucille Ave., Franklin Square, L. I., N. Y.)

Miniature Magnetic Pickup

A miniature magnetic pickup unit, for applications where weight is limited and space restricted, generates electrical voltage when excited by steel or iron moving into its magnetic field. It is recommended for such uses as rockets and guided missiles, and many other applications wherever minimum dimensions and weight for components are essential. (Electro Products Laboratories, Inc., Dept. SM, 4501 N. Ravenswood Ave., Chicago 40, Ill.)

Wrinkleproof Adhesive

A new adhesive that makes it possible for paper labels to lie flat and not lift up at the edges even on very round surfaces adheres to metal, glass, plastics, and fiber cartons. Nonflammable, waterproof, and stain resistant, the new adhesive may be applied by brush or used in conventional labeling machines. (Adhesive Products Corp., Dept. SM, 1660 Boone Ave., New York 60.)

Water Demineralizer

A compact, wall-mounted demineralizer that connects directly into any water line as simply as a filter does not require acid caustic regenerating solutions but employs a replaceable resin cartridge. This nonregenerative unit delivers demineralized water in continuous flow under pressure from 5 to 25 gal/hr (Barnstead Still & Sterilizer Co., Dept. SM, Lanesville Terrace, Forest Hills, Boston 31, Mass.)

New Type Mirror Coating

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Nylon Door Latch

This durable door latch for cupboards, cabinets, and many other uses is a tough nylon cylinder mounted on the underside of a cupboard or cabinet shelf. A metal plunger is screwed into the door directly opposite the position of the cylinder. As the door is closed, the cylinder engages the plunger, and the natural resilience of the nylon holds the door securely in place, yet permits easy opening. It keeps warped doors closed, is virtually unbreakable, noiseless, and has adjustable tension. (Laboratory Equipment Corp., Dept. SM, St. Joseph, Mich.)

Silicone Fluid

This new silicone fluid, which is remarkably compatible with organic materials, is water-white, odorless, and easily diluted with such materials as lanolin, beeswax, mineral oil, and 95 percent ethanol. This new fluid shows considerable promise as a release agent for specialized applications, an additive for paints and petroleum products, and a plasticizer for certain rubbers, resins, and plastics. (Dow Corning Corp., Dept. SM, Midland, Mich.)

Clinical Pacemaker

Producing closely regulated but adjustable serial pulses, this unit provides an output suitable for the control of heartbeat in case of cardiac standstill or conduction block. It can be used externally with either electrocardiograph-type, chest-strap electrodes or with hypodermic needles as electrodes, and in open-chest cases in direct contact with the ventricles. (Levinthal Electronic Products, Inc., Dept. SM, 2891 Fair Oaks Ave., Redwood City, Calif.)

Paper Electrophoresis Power Supply

A constant current power supply is designed and built specifically for paper electrophoresis. The selected current is electronically held constant under paper resistance changes, solvent evaporation, or line voltage fluctuations. The desired current is continually adjustable from 0 to 35 ma with control expansion at the lower values enabling fine settings. The output current is read from a large 4 in. two-range milliameter. (Matthew Laboratories, Dept. SM, 345 Nepperhan Ave., Yonkers 2, N. Y.)

Differential Converter

An instrument to measure the level of liquids in a closed tank, either under pressure or vacuum, converts differential pressure into proportionate air pressure, which in turn is transmitted to indicators, recorders, and controlling equipment. The instrument, which can withstand temperatures up to 350°F and is rated for pressures of 750 or 1500 lb/in.^{2}, utilizes a pneumatic balance weigh-beam system and is small and lightweight (28 lb). The range of the instrument is readily adjustable in field applications from 0 to 14 to 0 to 200 in. of water. (Minneapolis-Honeywell Regulator Co., Dept. SM, Industrial Division, Wayne & Windrim Ave., Philadelphia 44, Pa.)

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A highly soluble borate, especially adapted for the preparation of washable, fire-resistant coatings, is relatively neutral and is especially adaptable for use with coating grade polyvinyl acetate and in insulating and industrial wallboard coatings. (American Potash & Chemical Corp., Dept. SM, 3030 W. Sixth St., Los Angeles 54, Calif.)

Immersion Heater

The nickel-chrome heater, operating at 1700°F and radiating strongly in the far infra-red, can be used glowing-hot directly in an acid bath. It brings 250 ml of water to boiling in 3 min. (Fisher Scientific Co., Dept. SM, 717 Forbes St., Pittsburgh 19, Pa.)

Rubber Plastic

A new rubber plastic, which in itself is a complete formula for constructing molded, orthopedic appliances, simplifies the task of fabricating such appliances as arches and metatarsal pads. It requires no elaborate preparation and is resistant to both heat and perspiration. (Adhesive Products Corp. Dept. SM, 1660 Boone Ave., New York 60.)

High-Frequency Vibration Exciter

A small new shaker (Fig. 2) vibrates at frequencies up to 10,000 cy/sec for production vibration testing of subminiature electron tubes. It provides for rigidly clamping tubes in the vibrating armature and includes a flat-top table for use in calibrating small vibration pickups and accelerometers. Testing tubes with this shaker provide data on a tube's vibratory response and its ability to withstand severe vibration in service. (The MB Manufacturing Co., Dept. SM, New Haven, Conn.)

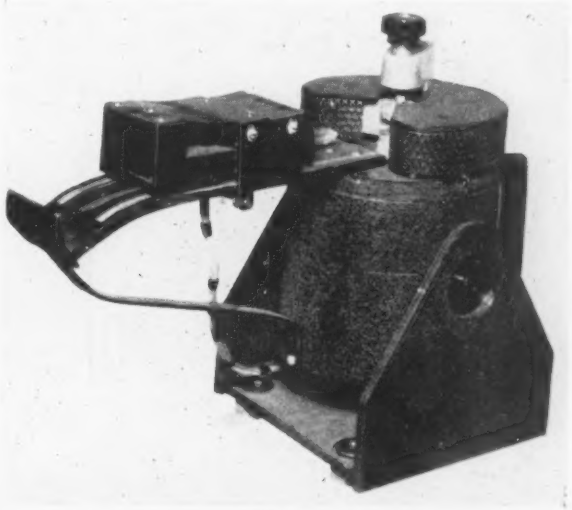

Fig. 2

Meetings

September

5–9. American Soc. of Human Genetics, Gainesville, Fla. (S. C. Reed, Univ. of Minnesota, Minneapolis 14.)

5–9. American Soc. of Ichthyologists and Herpetologists, Gainesville, Fla. (A. Grobman, Dept. of Biology, Univ. of Florida, Gainesville.)

5–9. American Soc. of Limnology and Oceanography, Gainesville, Fla. (B. H. Ketchum, Woods Hole Oceanographic Institution, Woods Hole, Mass.)

5–9. American Soc. of Naturalists, Gainesville, Fla. (W. Spencer, Dept. of Biology, Wooster College, Wooster, Ohio.)

5–9. American Soc. of Plant Physiologists, Gainesville, Fla. (J. F. Stanfield, Miami Univ., Oxford, Ohio.)

5–9. American Soc. of Plant Taxonomists, Gainesville, Fla. (R. C. Rollins, Gray Herbarium, Harvard Univ., Cambridge 38, Mass.)

5–9. Assoc. of Southeastern Biologists, Gainesville, Fla. (M. E. Gaulden, Biology Div., Oak Ridge National Laboratory, Oak Ridge, Tenn.)

5–9. Biometric Soc., ENAR, Gainsville, Fla. (A. M. Dutton, Box 287, Station 3, Rochester 20, N.Y.)

5–9. Botanical Soc. of America, Gainesville, Fla. (H. B. Creighton, Dept. of Botany, Wellesley College, Wellesley 81, Mass.)

5–9. Ecological Soc. of America, Gainesville, Fla. (J. F. Reed, Dept. of Botany, Univ. of Wyoming, Laramie.)

5–9. Genetics Soc. of America, Gainesville, Fla. (C. P. Oliver, Dept. of Zoology, Univ. of Illinois, Urbana.)

5–9. Mycological Soc. of America, Gainesville, Fla. (L. Shanor, Dept. of Botany, Univ. of Illinois, Urbana.)

5–9. National Assoc. of Biology Teachers, Gainesville, Fla. (J. P. Harrold, 110 E. Hines St., Midland, Mich.)

5–9. The Nature Conservancy, Gainesville, Fla. (G. B. Fell, 607 G St., SE, Washington 3, D.C.)

5–9. Phi Sigma Soc., Gainesville, Fla. (F. S. Orcutt, Dept. of Biology, Virginia Polytechnic Inst., Blacksburg.)

5–9. Sigma Delta Epsilon, Gainsville, Fla. (M. Gojdics, Barat College, Lake Forest, Ill.)

5–9. Soc of Protozoologists, Gainesville, Fla. (N. D. Levine, College of Veterinary Medicine, Univ. of Illinois, Urbana.)

5–9. Soc. for the Study of Evolution, Gainesville, Fla. (H. Lewis, Dept. of Botany, Univ. of California, Los Angeles 14.)

6–9. Conf. on the Physics of the Ionosphere, Cambridge, England. (J. A. Ratcliffe, Cavendish Laboratory, Cambridge.)

6–10. International Conf. of Geographic Pathology, 5th, Washington, D. C. (R. A. Moore, School of Medicine, Washington Univ., St. Louis 10, Mo.)

6–10. International Cong. of Clinical Pathology, 2nd, Washington D.C. (R. A. Moore, School of Medicine, Washington Univ., St. Louis 10, Mo.)

6–10. International Poliomyelitis Conf., 3rd, Rome, Italy. (S. E. Henwood, 120 Broadway, New York 5.)

6–11. International Soc. of Hematology, 5th, Paris, France. (S. Haberman, 3600 Gaston Ave., Dallas, Tex.)

7. Phycological Soc. of America, Gainesville, Fla. (R. H. Thompson, Dept. of Botany, Univ. of Kansas, Lawrence.)

7–10. Alaska Science Conf., 5th, Anchorage, Alaska. (AAAS, Box 960, Anchorage.)

8–9. Soc. of General Physiologists, annual, Woods Hole, Mass. (J. B. Buck, National Institutes of Health, Bethesda 14, Md.)

8–10. American Physiological Soc., Madison, Wis. (W. B. Youmans, Dept. of Physiology, Univ. of Wisconsin, Madison.)

8–10. American Soc. of Mechanical Engineers, fall, Milwaukee, Wis. (O. B. Schier, II, 29 W. 39 St., New York 18.)

8–10. American Sociological Soc., Urbana, Ill. (J. W. Riley, Jr., A.S.Soc., New York Univ., New York 3.)

9–11. American Political Science Assoc., annual, Chicago, Ill. (J. Gange, 1785 Massachusetts Ave., NW, Washington 6, D.C.)

9–17. International Cong. of Ophthalmology, 17th, Montreal, Canada, and New York, N.Y. (W. L. Benedict, 100 First Avenue Bldg., Rochester, Minn.)

10–13. Inst. of Mathematical Statistics, American Statistical Assoc., and Econometric Soc., Montreal, Canada. (K. J. Arnold, Dept. of Mathematics, Michigan State College, East Lansing.)

10–16. International Symposium on Problems in Contemporary Optics, Florence, Italy. (S. S. Ballard, The Rand Corp., Santa Monica, Calif.)

10–24. American Soc. of Photogrammetry, Philadelphia, Pa. (C. E. Palmer, 1000 11 St., NW, Washington 1, D.C.)

12–16. American Inst. of Chemical Engineers, Glenwood Springs, Colo. (C. H. Prien, Research Inst., Univ. of Denver 10, Colo.)

12–16. Illuminating Engineering Soc., Atlantic City, N.J. (A. D. Hinckley, 1860 Broadway, New York 23.)

12–17. American Chemical Soc., annual, New York City. (R. M. Warren, 1155 16 St., NW, Washington 6, D.C.)

12–17. International Assoc. for the Prevention of Blindness, New York City. (Prof. Franceschetti, 3 Ave. Miremont, Geneva, Switzerland.)

12–17. International Cong. of Cardiology, Washington, D.C. (L. W. Gorham, American Heart Assoc., 44 E. 23 St., New York 10.)

12–17. International Organization Against Trachoma, Montreal, Can. (A. Sorsby, 45 Lincoln's Inn Field, London W.C.2.)

13–14. American Microscopical Soc., annual, Philadelphia, Pa. (C. J. D. Brown, Dept. of Zoology and Entomology, Montana State College, Bozeman.)

13–15. Analytical Instrument Clinic, 3rd annual, Philadelphia, Pa. (A. H. Peterson, 4400 5 Ave., Pittsburgh 13, Pa.)

13–17. Assoc. of Applied Biologists, 50th anniversary, London, Eng. (R. K. S. Wood, Imperial College of Science and Technology, London, S.W.7.)

13–18. International Cong. of Nutrition, 3rd, Amsterdam, Netherlands. (M. van Eekelen, 61 Catharynesingel, Utrecht, Netherlands.)

13–19. International Cong. on Industrial Medicine, 11th, Naples, Italy. (Sec. of Cong., Istituto Medicine del Lavoro, Universita, Policlinico, Piazza Miraglia, Naples.)

13–19. International Soc. of Blood Transfusion, 5th, Paris, France. (Col. Julliard, 57 Boulevard d'Auteuil, Boulogne sur Seine, France.)

(*Continued on page* x)

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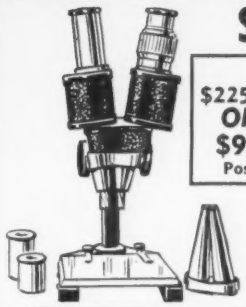

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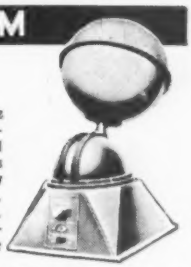

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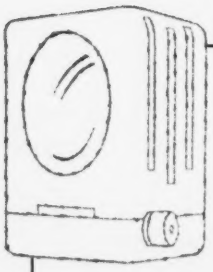

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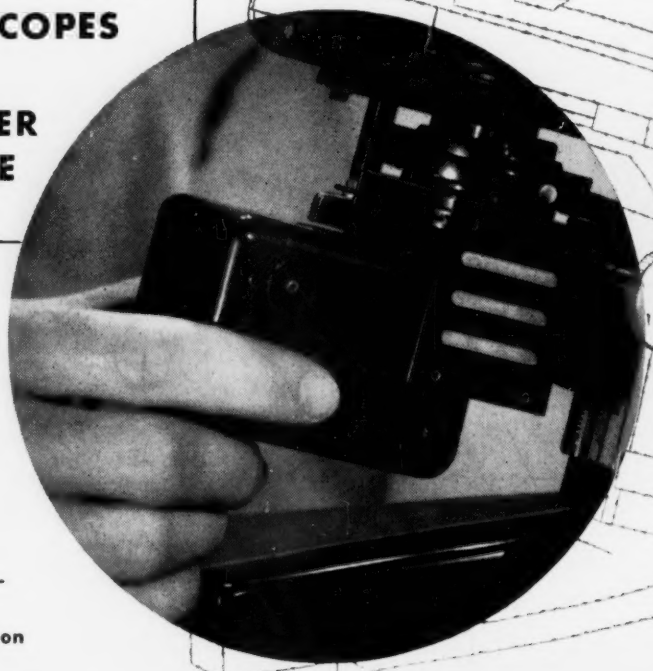

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MORRIS C. LEIKIND

Mr. Leikind received his training at the Ohio State University, Harvard, the Johns Hopkins School of Hygiene and Public Health, and the Johns Hopkins Institute of the History of Medicine. He has served as Consultant in Science and then as Science Specialist in Biology and Medicine at the Library of Congress. Mr. Leikind is now chief of the Historical Research Division in the Medical Museum of the Armed Forces Institute of Pathology in Washington, D.C. He also teaches a course on the history of biology in the U.S. Department of Agriculture Graduate School.

THE transfer of the Armed Forces Institute of Pathology from its old home on 7th and Independence, S.W., in downtown Washington to its new building on the grounds of the Walter Reed Army Medical Center is the culmination of a dream of long ago. With this transfer an era ends and a new one begins, and it therefore seems appropriate to look backward through a half-silvered mirror, as it were, which will reveal not only something of the past but perchance a glimpse of the future.

The Armed Forces Institute of Pathology is both an old and a new institution. It is new in that the "AFIP" was established on July 6, 1949, when it was officially named and designated as a central diagnostic, research, and teaching center for pathology to serve the needs of the Army, Navy, Air Force, and the Veterans Administration, together with the Public Health Service and other civilian branches of the Government that may require its services. But the Armed Forces Institute of Pathology is an old institution in that it has evolved from and, indeed, includes within its new organization the Army Medical Museum, familiar not only to generations of physicians, medical students, and scientists but to thousands of tourists as well.

Established in 1862, the Medical Museum, now approaching its first centennial, has undergone

changes in organization and recently in name, which are perhaps the best evidence that this institution is a vital and evolving organism that has grown out of human needs and is directly responsive to them. When John Masefield wrote some years ago about "dead museums and miles of misery . . . uprooted from man's needs," he certainly was not describing the Army Medical Museum. For if there is one circumstance that stands out above all others in the origin of the Army Medical Museum it is that the Museum was created in direct response to a desperate human need.

The Museum was founded by the Surgeon General of the Army, William Hammond, one of the most controversial figures in American military medical history. Hammond was born on Aug. 28, 1828, at Annapolis, Md. He began the study of medicine at the age of 16 and received his medical degree from the Medical Department of the City of New York when he was 20. After an internship and a brief period of private practice in Saco, Me., he entered the Army Medical Service in 1849.

Despite a lively and active period of service with troops against the Indians in various western posts, he found time for physiological and botanical investigations and in 1857 he published an essay on "Experimental research relative to the nutritive value and physiological effects of albumen, starch and gum, when singly and exclusively used as a food," which was awarded the American Medical Association prize.

In 1860, he was offered the chair of anatomy and physiology at the University of Maryland.

William A. Hammond (1828–1900), Surgeon General, U.S. Army and founder of the Army Medical Museum.

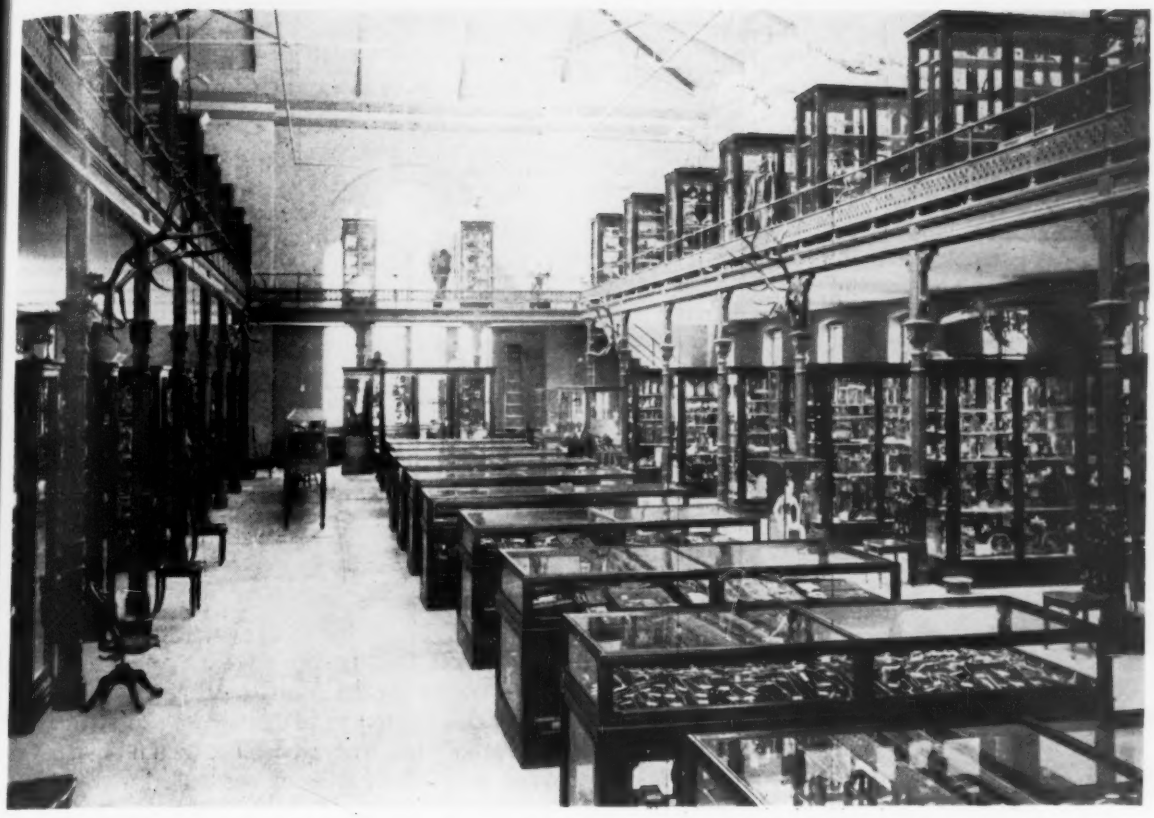
Hammond resigned from the Army to accept this position, but his academic career was short-lived, for on May 2, 1861, he reentered the Army as Assistant Surgeon but at the bottom of the promotion ladder at which he had earlier held a high place; however, his vigor and administrative talents soon attracted the attention of the Sanitary Commission, a body that had been appointed by the Secretary of War, Simon Cameron, to inquire into and advise on sanitation in the Army. The Commission quickly found that conditions were appalling: hospitals were poor and inadequate; there was no organized transport for sick and wounded; and, in the words of Ashburn "the Medical Department was fossilized and ignorant of the fact." Reform, it was decided, would have to be revolutionary and a new Surgeon General was necessary. William A. Hammond was recommended by the Commission for this extremely important position when he was only 34 years of age, and he was appointed Surgeon General on Apr. 25, 1861.

Hammond served in this office for a year and a half, a period marked not only by great friction within the department resulting ultimately in Hammond's court martial and dismissal (a verdict later reversed), but, and this is of greater importance, also by high administrative efficiency and many important accomplishments.

Among the most notable of these accomplishments was the creation of the Army Medical Museum. General Hammond had already been struck by the enormous mass of material that was being made available through the carnage of a war unprecedented in magnitude in American military history. He recognized the opportunity for collecting and preserving this pathological material and making it available for study, for he had already seen armies staffed by doctors who had never even seen the diseases and wounds they were called upon to treat. Thus it was that from the Surgeon General's Office on May 21, 1862, there emanated Circular No. 2, which read:

> As it is proposed to establish in Washington, an Army Medical Museum, medical officers are directed diligently to collect and to forward to the office of the Surgeon General, all specimens of morbid anatomy, surgical and foreign bodies removed, and such other matters as may prove of interest in the study of military medicine or surgery. These objects should be accompanied by short explanatory notes. Each specimen in the collection will have appended the name of the Medical Officer by whom it was prepared.

Brief and direct as this circular was, it remains nevertheless an extraordinary document when viewed against the background of the medical his-



Main Museum exhibit hall as it was prior to World War I and as many still nostalgically remember it.

tory of its time, for General Hammond actually advocated much more than the establishment of a medical museum. What he really had in mind was the development of a great graduate school of medicine in Washington where medical officers of the Army would be kept abreast of new advances in science and medicine.

Thus, in addition to the medical museum, Hammond envisioned an Army Medical School as well, both institutions to be associated with a great general hospital to provide a center for clinical instruction.

To appreciate how far-reaching these proposals were, let us recall briefly the state of medical education and research in the United States just prior to the Civil War. In this antebellum period, as Shryock has so aptly written:

> The lack of public or private support for pure science, the consequent dependence on practice, the demand for utility at just the time when candid doctors could promise least, the deterioration of medical personnel—all these and other factors inhibited systematic investigations. Practically no men in this period had what could be called research careers, and no cities were truly research centers. American medical science on the eve of the Civil War was still colonial in nature. Physicians had learned much and had acquired some understanding of how more knowledge could be obtained, but they still depended upon Europeans to provide this progress.

And in this antebellum period what were the Europeans providing? Virchow's theory of "Cellular Pathology" was scarcely out of its swaddling clothes; Pasteur was embroiled with Pouchet in an argument on spontaneous generation, a polemic that cleared the ground for establishing the germ theory of disease; Lister of England was just about to begin his observations and experiments that developed the principles of antiseptic surgery. Only one major contribution to medicine had come from America during this period, the gift of anesthesia, demonstrated by W. T. G. Morton at the Massachusetts General Hospital in Boston 16 years before the opening of the Army Medical Museum.

And there were other developments in science, not as spectacular as the aforementioned ones, which were also destined to have an influence on the newly created institution. Thus, advances in optics and in glass technology made possible vast improvements in microscopes and in microscopy. In addition, the discovery of aniline dyes by the English chemist Perkin, and their subsequent application as biological stains, provided another significant tool for probing the secrets of the cellular

John H. Brinton, first curator of the Army Medical Museum.

basis of pathology and the mysteries of the etiology of infectious diseases.

We must view the opening of the new institution in the light of these developments and also the fact that there was no comparable medical museum on the North American continent and few like it abroad.

Following Hammond's circular came orders to the medical officers directing them to make complete records of fractures, amputations, gunshot wounds, and other traumatic conditions, along with diseases such as fevers, dysenteries, and scurvy.

The reason for emphasis on adequate records and case histories was that General Hammond also envisaged a "Medical and Surgical History of the War of the Rebellion," a work that would be based largely upon records and specimens collected by and for the Museum.

The Museum became a physical reality on Aug. 1, 1862, and Dr. John Hill Brinton was its first curator. In an address delivered at the Army Medical School many years later, Brinton said:

> The beginning of the Museum in August 1862 was very modest, consisting of three dried and varnished specimens placed on a little shelf above the inkstand of the desk of the recently appointed Curator.

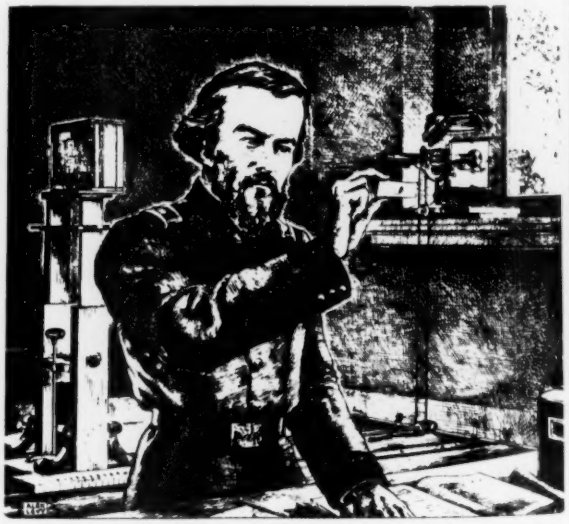
Yet within 8 years the growth of the Museum was so phenomenal that in 1870 Dr. Berenger-Ferrand of Paris wrote that

> The United States has done as much in the matter of an anatomical-pathological museum in five years as has been done in all Europe in a century.

And, again in 1870, St. George Mivart wrote in *Nature*:

> The Army Medical Museum contains a series of excellently numbered preparations of great professional interest remarkable chiefly for its profuse exhibition of the effects of shot, shell and other implements of war on the human frame. The material for this museum was chiefly collected during the American Civil War. It may well be said that the Americans are a wonderful people. There are few other nations which would have been capable of so utilizing the results of a protracted internecine war as to make them available in after years toward the advancement of medical science and the alleviation of human pain.

During this time, the Museum had not only assembled and organized several thousand surgical and medical specimens, it also began to branch out into fields related to pathology and to take on the character of a true medical museum. In 1863, a photographic department was added under the direction of Surgeon J. J. Woodward, a pioneer in medical photography. It is highly probable that the first photomicrographs in America were made by Woodward in the Museum. His original apparatus, negatives, and prints are still preserved, and some of his pictures, made with what are now con-



Joseph Janvier Woodward 1833-1884

Joseph J. Woodward (1833–84). In the background may be seen the photomicrographic apparatus used by Woodward. The microscope sat on the window ledge with its mirror protruding outside to catch and reflect sunlight through the lenses to the camera.

Instruments devised by J. J. Woodward for measuring the numerical aperture of microscope objectives. Woodward's notebook recording studies on the resolving power of microscope objectives is alongside.

sidered crude instruments, have not been surpassed by modern cameras and microscopes.

With the continued physical growth of the Museum, space became (as it is today) a problem of paramount importance, and four moves were necessary before it was moved in 1887 into what was to be its home for almost three-quarters of a century, the old red brick building on the corner of 7th and Independence, a home it shared and still shares with the Army Medical Library, now the Armed Forces Medical Library.

One of the early sites for the Museum was the old Ford's theatre where Lincoln was shot. While it was in these quarters, the Museum was open to the public, since so many persons who came to see the place where Lincoln was shot stopped to examine the specimens and the Museum acquired a reputation among tourists as one of the "must" sights in Washington. Present attendance figures of more than 150,000 visitors per year testify to the continuing drawing power of the Museum.

Nevertheless, those who organized and directed the Museum in its early days were not satisfied with merely collecting specimens. They recognized the important scientific potentialities of this vast assemblage of material and were already putting it to use. As mentioned earlier, Hammond had conceived the idea of a school of military medicine to be associated with the Museum. This remained a dream for 30 years before it became a reality in 1893. Nevertheless, Woodward and others were already giving lectures and demonstrations to members of Congress, physicians, members of the National Academy of Sciences, and even lay groups interested in medical problems.

When in 1878 the massive *Medical and Surgical History of the War of the Rebellion,* by J. J. Woodward, C. Smart, G. A. Otis, and D. A. Huntington was completed, it received world-wide acclaim. It was highly praised by Virchow and other European authorities, and Garrison describes it as "undoubtedly the most important contribution to military medicine and surgery which had yet been made."

In 1883 occurred an event of great significance. John Shaw Billings was placed in charge of both the Army Medical Library and the Museum, and during his command the Museum grew tremendously. A new classification of the specimens was worked out, circulars soliciting specimens were issued, a collection of medical medals was begun together with a collection of microscopes. This assemblage of microscopes, incidentally, has grown enormously and is regarded as one of the largest

if not the largest collection of its kind in the world. Serial sections of fetuses were prepared and stained, and a notable group of anatomical transparencies were assembled. In 1888, Billings made a remarkable address to the Congress of American Physicians and Surgeons meeting in Washington that year. It was entitled "On medical museums with special reference to the Army Medical Museum at Washington." This address is still worth reading today, and in it Billings laid down a set of principles on the purposes and scope of the Museum which still serve as guideposts.

In this address, Billings pointed out that the Army Medical Museum was in reality the National Medical Museum and that, to perform its functions adequately, it must strive for closer relationships with the civilian medical profession. Billings also showed that the Museum beyond being a collection of merely medico-military subjects, must also include anatomy, embryology and physiology, anthropology, and general pathology, together with instruments and items of medico-historical interest. It thus became necessary, Billings argued, to consider how best to organize the Museum and arrange its contents for the benefit of all medical men, students and research workers, and, last but not least, the serious layman.

When Billings left his post for other activities, the Museum was already on a sound foundation.

Around the turn of the century, interest in pathological anatomy declined, coincident with the rise of bacteriology and immunology and their applications. This was reflected in the Museum, since little anatomical material was added until World War I. In the meantime, the Army Medical School had been founded in 1893 with is first quarters in the Museum. Its emphasis was on the rapidly developing field of preventive medicine, and so it was in the Museum quarters that Colonel Frederick Russell prepared the early typhoid vaccine that was used for the great mass inoculation of the soldiers in the U.S. Army. This experiment, which confirmed the results obtained by Wright who inoculated several thousand men in the British and Indian armies, helped establish the efficacy of antityphoid inoculation as a preventive measure against this disease.

During this same period, Walter Reed served as curator of the Medical Museum and also was the first professor of bacteriology in the newly established Army Medical School. Here Reed planned his brilliant experiments that enabled him and his collaborators, Lazear, Carroll, and Agramonte to verify the hypothesis of Carlos Finlay that a specific mosquito was, indeed, the vector of yellow fever.

And here also in the laboratories of the Medical Museum, Walter Reed and his assistants were in correspondence and consultation with a host of doctors, civilian as well as military, who required counsel and advice on problems of bacteriology and pathology. Thus were foreshadowed the diagnostic and research activities and the close liason with the medical and scientific community that are now so important in the program of the Armed Forces Institute of Patholgy.

The period between the Spanish American War and the outbreak of World War I was one of limited activity for the Museum. However, with our entry into the European conflict, the dormant interest in pathological anatomy was revived somewhat. Twenty-two thousand specimens, together with 21,000 autopsy protocols, were added to the collections, illustrating lesions of influenzal pneumonia, tuberculosis, and gas gangrene as well as effects of war wounds and of poison gases.

The Medical Illustration Service, a branch of the Medical Museum, made one of the most significant contributions to the war effort by developing the largest motion-picture laboratory in the country. This service prepared 137 training films for the Armed Forces, many of these being useful to the civilian medical profession.

After the war, the photographic laboratory continued as one of the most active departments of the Museum, and perhaps its most notable contribution during this period was the development of the Carter-Reeve process of color photography, one of the greatest modern advances in the pictorial representation of pathological materials.

Immediately after the war, there began another phase in the growth of the Museum. By this time, the amount of material in the pathology collection had grown tremendously, and many of the wax models, moulages, and relics of the old Museum were being displaced. Furthermore, advances in medical science had already indicated that case histories together with related histopathological material and gross specimens were of greater value for diagnosis and research than collections of large numbers of miscellaneous specimens.

It was also recognized that, with the formation of mass armies composed of citizen soldiers who would fight not only on home soil but in distant lands as well, the concept of military medicine had to be broadened. Thus, all aspects of pathology and not merely those from conditions previously considered to be of military importance came to be included.

Shortly after World War I, two additional developments took place. First the Army Medical Museum was designated as the Central Laboratory

Quarters occupied by the the Army Medical Museum and the Armed Forces Institute of Pathology from 1862 to 1954. (Top left) Riggs Bank Building, 1862–63. (Bottom left) Pennsylvania Avenue, 1863. (Top right) Corcoran School House, 1325 H Street, N.W., 1863–66. (Bottom right) Ford's Theatre, 1867–87. (Center) 7th and Independence Avenue, S.W., 1887 to present.

of Pathology for the Army. Thus, specimens and case histories from every military autopsy and from all important surgical operations in all Army hospitals were ordered to be sent to the Museum for review and filing. Second, in 1922, Major (now Brigadier General) George B. Callendar, M.C., U.S.A., Ret., and curator of the Museum, was instrumental in establishing the first of the Registries of Pathology, which now occupy such an important place in American medicine. These registries, vastly expanded by Colonel J. E. Ash, M.C., U.S.A., Ret., who served as curator of the Museum and as director of the Army Institute of Pathology, are large collections of histopathological materials, gross specimens, and related case histories, contributed not only by military hospitals but by members of various specialized medical groups and societies. Thus, there are concentrated under one roof large collections of material such as no other single institution can hope to acquire.

A registry as described by Colonel Ash is:

> . . . a central agency for the collection of pathologic material and related clinical, laboratory, x-ray and other data in a specified field of pathology so organized that the cases can be properly processed and made available for study and research. Living patients are followed periodically so that eventually a sufficient number of life histories of patients with the particular condition can be accumulated to form the basis for definitive studies.
>
> These studies include morphologic and statistical analyses, the establishment of the diagnostic and prognostic criteria and the evaluation of treatment.

The first of the registries was established through the cooperative efforts of the American Academy of Opthalmology and Otolaryngology, the American Ophthalmologic Society, the Ophthalmic Section of the American Medical Association, and the Surgeon General of the United States. Twenty-two registries representing as many different specialties now find their homes here.

But the formation of the Registries of Pathology was not the only contribution that Major Callendar made. He also made a notable series of experimental studies on wound ballistics, which added much to our knowledge of this subject. They were of practical importance and also reflected a

recognition of the fact that experimental pathology was an important aspect of the work of the Museum and served to emphasize the need for expanded facilities for such work, a need now happily to be satisfied in the new AFIP building.

During World War II, the Museum activities expanded enormously. It acquired, first unofficially and then officially, the name of the Army Institute of Pathology, which reflected more accurately its expanded activities.

During the war, the Institute was represented by photographic teams and collection groups in every theatre of conflict. The availability of its consultative and diagnostic services to military surgeons on the far-flung battle fronts was illustrated by the fact that specimens from patients in India were examined, and reports were returned within 11 days after they were sent off to Washington.

In addition, vast numbers of training films, atlases of diseases, and special reports on numerous special pathological problems were issued. Notable among these were the studies on infectious hepatitis and on frost-bite and cold injury. As the war came to a close, the Army Institute of Pathology was entrusted with the task of studying the pathology of atomic-bomb casualties.

From 1942, the expanded activities of the Army Institute of Pathology, as the Museum was already informally known, created such a demand for space that a large part of the Museum's collection was placed in storage. Thus the public display areas virtually disappeared for the "duration." Not until 1947 was the Museum reconstituted across the street from its former quarters in a temporary building designed originally for the use of a detachment of SPARS, the women's component of the Coast Guard.

After the war, a special committee of the National Research Council was appointed to consider the future of the Institute. This committee recommended in 1945 that the Institute be divided into four operating departments. The Department of Pathology, the Army Medical Illustration Service, the American Registry of Pathology, and the Army Medical Museum. In 1946, the Institute was designated as the Central Laboratory of Pathology for the Veterans Administration.

At about this time, the Hawley Board and Hoover commission recognized the Institute's unique place in the medical affairs of our armed services and urged further expansion and autonomy. Thus it was that, on July 6, 1949, under the Act unifying the Armed Services, the Army Institue of Pathology was redesignated the Armed Forces Institute of Pathology within the Department of Defense. It operates under the joint guidance of a Board of Governors, consisting of the Surgeons General of the Army, Navy, and Air Force and a Scientific Advisory Board.

The teaching activities of the Institute were also vastly expanded, taking advantage of the almost limitless materials already assembled in the Museum and the Registries. Thus, it is possible for postgraduate scholars and investigators to spend periods of 1 week to several years at the Institute. In addition, the publication of a number of atlases, sponsored by the Registries, together with loan sets of slides, makes it possible for any physician, civilian or military, to draw upon the resources of this great institution.

Coincident with this change, the need for a new building was recognized, and plans were drawn for such a structure on the grounds of the Walter Reed Army Medical Center. On July 10, 1951, with impressive ceremonies, ground was broken and on Oct. 20, 1953, the cornerstone of the almost completed structure was laid. Thus at long last, the dream of William A. Hammond bears its final fruit, for now joined in physical proximity on the ground of the Walter Reed Army Medical Center are the Army Medical School, now the Research and Graduate School, the Army Medical Museum, now the Armed Forces Institute of Pathology, and the great hospital that Hammond envisioned.

It is thus seen that the Museum itself has grown into a vast new institution. Yet it has not been obliterated, for the Museum stands in relation to its offspring as a reservoir to both the streams that feed it and the rivers that emanate from it. It is a storehouse wherein are collected the raw materials for the study of disease and its manifestations by research workers who seek new knowledge and by students who need to acquire knowledge of what is already known and must organize it as a basis for new knowledge, and finally the Museum is a place where the layman may see what medical science is doing and has done in its never-ending battle against disease.

As the Armed Forces Institute of Pathology prepares to move into its new building, it is perhaps appropriate to recall the words spoken by the Honorable Melvin A. Casberg, Assistant Secretary of Defense at the cornerstone-laying ceremony on Oct. 20, 1953:

> It seems fitting to me that the first permanent structure to be erected by the unified Armed Forces was not an arsenal or a factory for tanks, airplanes, or battleships. Instead, we have this institute which is useful in peace as well as war, and which is dedicated to the advancement of science in the service of humanity.

Armed Forces Institute of Pathology: Retrospect and Prospect

HUGH G. GRADY

Dr. Grady has been on the staff of the AFIP since 1948 and was appointed scientific director, American Registry of Pathology in 1949 and acting chief, Division of Pathology, Armed Forces Institute of Pathology in 1954. He received his M.D. from Jefferson Medical College in 1934. He was formerly on the staff of the National Cancer Institute and Jefferson Medical College.

THE Armed Forces Institute of Pathology has long since outgrown its present home and the transition to new and adequate quarters is an opportune time for assessment of the past and at least a sketch of future hopes. The fundamentals of its present organization stem back to the beginning of World War II when the great expansion of Army strength necessitated a substantial enlargement of the professional staff. Chiefly because of the efforts of J. E. Ash, who was then curator, and the late Balduin Lucké, a reserve officer on active duty, a well-rounded staff was organized with a number of its members interested in some particular phase of pathology. Instead of the usual pyramidal structure of a university department, the Army Medical Museum, as it was then known, was staffed largely by experienced men, some of them established authorities in their fields. The development and expansion of the American Registry of Pathology was greatly facilitated by the new staff.

During this period, a large number of consultants, most of them professors of pathology, were appointed and worked a week or more at the Museum each year, taking an active part in the daily work and devoting some time to investigation. Informality and enthusiasm provided a stimulating atmosphere that few of the staff will ever forget. In addition to a large volume of routine work, many of the staff interested themselves in broad phases of military pathology. Infectious hepatitis was an urgent problem in the early days of the war, and Balduin Lucké made a major contribution to our understanding of the pathology of fatal hepatitis. At a later date, Lucké and Tracy Mallory described the changes in the fulminant form of the disease.

Ash and Spitz published *Pathology of Tropical Diseases* in answer to the needs of pathologists who were suddenly faced with unfamiliar diseases encountered in the South Pacific, Asiatic, and Mediterranean areas. The list of major contributions is a long one, and many of them were published in 1946 in a special issue of the *Military Surgeon* that was dedicated to J. E. Ash on his retirement. Mention should be made of Lucké's work on lower nephron nephrosis, Allen and Spitz' work on the pathology of Rickettsial diseases, Friedman and Moore's work on an astounding series of testicular tumors, Haymaker's work on the pathology of heat stroke, Friedman's work on trench foot and high-altitude frostbite, French and Dock's work on coronary arteriosclerosis in young soldiers, and Custer's work on aplastic anemia following the use of Atabrine.

The end of the war brought with it a certain amount of reorganization, the addition of civilians to the military staff, and the change in title to Army Institute of Pathology and eventually to Armed Forces Institute of Pathology. However, the basic patterns of the war years were retained, although they were greatly expanded first by the liaison with the Veterans Administration and later by the 1949 unification plan.

The Division of Pathology, the heart of the Institute, is organized in sections covering most of the specialties in pathology. But the volume of work as measured by accessions more than tripled over the war years, and the difficulties of crowding in an ob-

solete building were only partially solved by overflowing into several of Washington's hallmarks, the "temporary" building.

These years, however, were marked by the publication of the report on *Pathology of Atomic Bomb Casualties* by Liebow, Warren, and DeCoursey, the fundamental studies of Wilder on nematode endophthalmitis and her discovery of toxoplasma as an etiologic agent in uveitis, a definitive study of bone marrow embolism by Rappaport, Raum, and Horrell, a description of nonchromaffin paraganglioma by Smetana and Scott, and a monographic treatment of the Landry-Guillain-Barre syndrome by Haymaker and Kernohan.

The facilities of the AFIP, including a printing press, were made available to the National Research Council for the publication of the *Atlas of Tumor Pathology*. To date, 13 fascicles have been published out of a projected total of more than 30. The American Registry of Pathology has continued to publish a number of syllabuses complementary to the loan sets, and the 4th edition of the *Atlas of Ophthalmic Pathology* has been issued in greatly expanded form by W. B. Saunders Company. The Museum proper has been substantially refurbished, though no better housed, and the Medical Illustration Service has turned out exhibits and visual aids. In addition, it has supervised the making of motion pictures and produced photomicrographs by the thousands.

Young pathologists of the Army, Navy, Air Force, Veterans Administration, and Public Health Service and young men from universities and hospitals, American and foreign, have been trained; and countless visitors, including interns, professors, and research students, have come to the AFIP to study for 1 day or 6 months.

In spite of the activity and productivity of the past 15 years, it has been obvious that sound and balanced development of the Institute required not only adequate space but, more importantly, facilities for experimental work. It has taken a long time to design and produce this new building, and many battles, some with the necessities of history and some with bureaucracy, have had to be fought and won.

As Colonel Vorder Bruegge's article points out, the new building has been designed with a view to the utmost flexibility. Each senior member of the staff will have a basic laboratory unit, but, in addition, there will be larger, more or less elaborate facilities for work, particularly in the fields of histochemistry, electron microscopy, and radiobiology. These represent logical extensions of research in pathological problems in which the AFIP is vitally interested. Although it may be difficult to recognize the AFIP of 1955 from that of 1935, it will still be an Institute of Pathology with a fundamental interest in the morphology and behavior of diseases affecting both the military and civilian populations. It should, however, be in a position to fulfill in a much more efficient and satisfying manner its threefold mission of consultation, teaching, and research.

On Museums

When a museum building has been provided, and the nucleus of a collection and an administrative staff are at hand, the work of museum-building begins, and this work it is hoped, will not soon reach an end. A finished museum is a dead museum, and a dead museum is a useless museum. One thing should be kept prominently in mind by any organization which intends to found and maintain a museum, that the work will never be finished; that when the collections cease to grow, they begin to decay. A friend relating an experience in South Kensington said: "I applied to the man who sells photographs of such edifices for pictures of the main building. He had none. 'What, no photographs of the South Kensington Museum!' I exclaimed, with some impatience. 'Why sir,' replied the man mildly, 'you see the museum doesn't stand still long enough to be photographed.' And so indeed it seems," continued Mr. Conway, "and this constant erection of new buildings and of new decorations on those already erected, is the physiognomical expression of the new intellectual and aesthetic epoch which called the institution into existence, and is through it gradually climbing to results which no man can foresee."

My prayer for the museums of the United States and for all other similar agencies of enlightenment is this—that they may never cease to increase.—George Brown Goode, "Museums of the future," *Report of the U. S. National Museum, 1897*, pt. 2 (1901).

New Building Facilities for Armed Forces Institute of Pathology

COLIN F. VORDER BRUEGGE

The author, who is a lieutenant colonel in the Medical Corps of the U.S. Army, is assigned as a senior pathologist and special assistant to the director for planing at the Armed Forces Institute of Pathology, Washington, D.C. He is AFIP representative in the group that planned the new facilities. Colonel Vorder Bruegge received his M.D. at the University of Tennessee in 1939. Following internship and a fellowship in pathology, he entered the U.S. Army Medical Corps in 1941. During World War II, he served as chief of Laboratory Service in general hospitals in England and France. He was commanding officer of the 7th Medical Laboratory in Munich and chief of the Preventive Medicine Division in the Surgeon's Office, Headquarters, Berlin District, Germany.

A NEW building for the Armed Forces Institute of Pathology is almost completed and occupancy is planned for the early autumn of 1954. The building is located on the grounds of the Walter Reed Army Medical Center and replaces the existing building at 7th Street and Independence Avenue, S.W., Washington, D.C., which has housed the AFIP since 1887.

Design features are as varied as the interests of staff members who will use the facilities. But underlying the apparent complexity are relatively few fundamental concepts. The purpose of this article is to discuss these basic design principles from the standpoint of a pathologist. The architectural and engineering details have been summarized in appropriate publications (*1, 2*).

The actual planning of the building was preceded by thorough preparation, including many inspection trips to industrial laboratories and other medical research laboratories, in order to obtain maximum benefit from the experiences of others. To assure the inclusion of design features of value to both the current and the anticipated AFIP activities, detailed studies were made of all AFIP operational and interdepartmental liaison requirements. The size, type, and space-assignment patterns of the building are based on these studies.

The building was designed by Faulkner, Kingsbury, and Stenhouse, architects, of Washington, with Guy B. Panero, Engineers, Inc., of New York and Washington as consulting mechanical engineers and James M. Gongwer of Washington as consulting structural engineer. The Cramer-Vollmerhausen Co., Inc., of Washington was awarded the contract for construction. The entire project was supervised by the district engineer, Washington District, Corps of Engineers, U.S. Army. Representatives of AFIP were assisted in the planning of unique facilities and guided in the preparation of basic design data for the architect-engineer by Carl R. Mylius, supervising architect, Office of the Surgeon General, Department of the Army. Valuable assistance in planning the equipment has been received from George Allan, Office of the Surgeon General, and Major John T. Maloney, AFIP.

Basic Design Concepts and Construction Details

The eight-story reinforced concrete bomb-resistant building has a gross area of approximately 215,000 ft² and a net usable area of 130,000 ft². There are five floors aboveground and three floors underground, and except for two end wings, no windows are provided. Unbroken exterior concrete surfaces are relieved by a rough-textured paneled pattern, achieved by placing in opposite directions and in alternate panels the boards for the forms in which the concrete was cast.

Bomb-resistant construction. Several of the most distinctive features resulted from the design for protective construction. For example, the main, central windowless mass, measuring 206 by 102 ft, consists

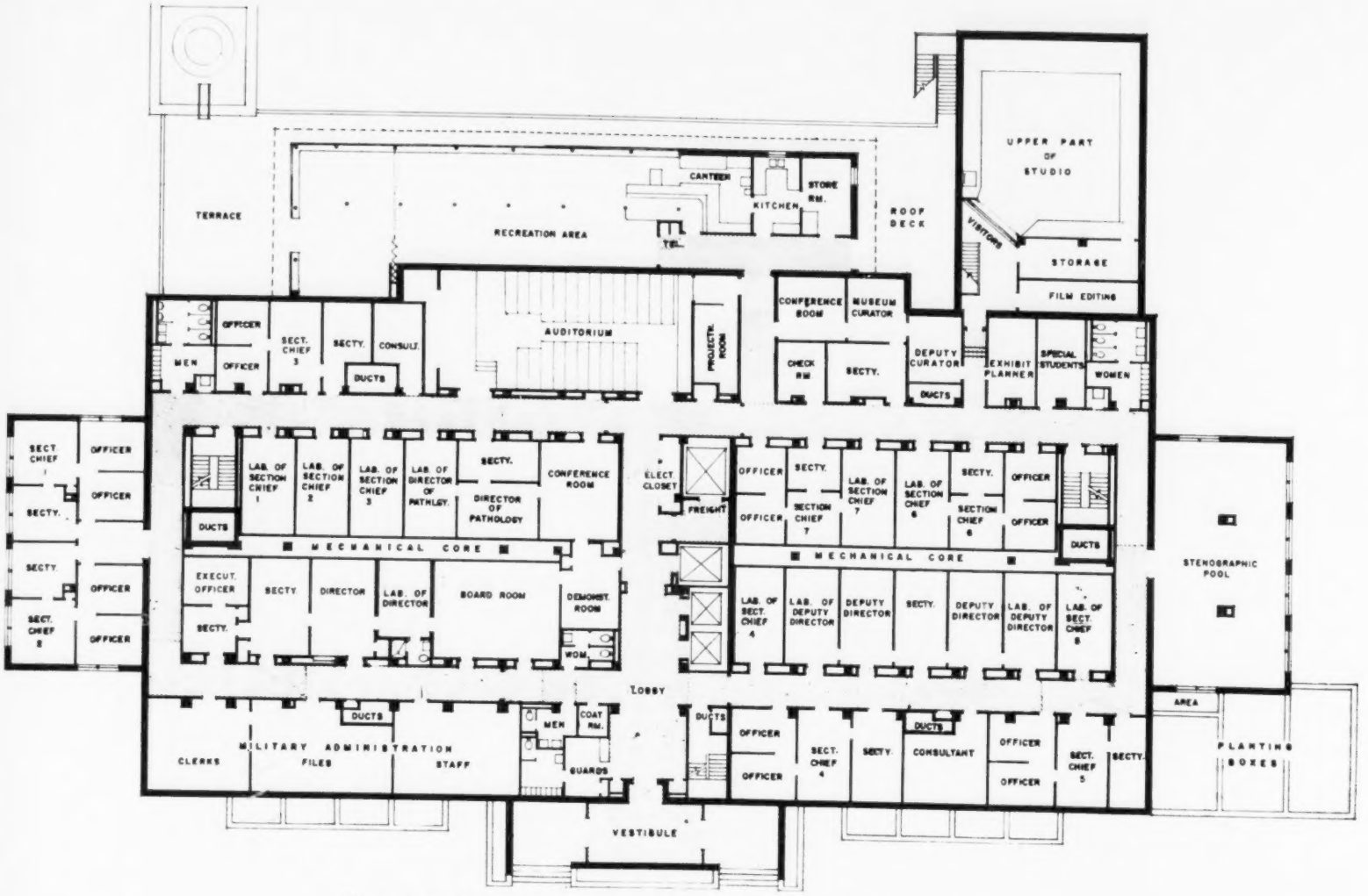


Fig. 1. First-floor plan of the Armed Forces Institute of Pathology building.

essentially of a reinforced monolithic concrete "box" with almost half of its volume underground. Ceiling heights of the underground floors are adequate to permit double tiers of file areas, thus providing space for valuable and irreplaceable records and material not only within a sturdy building but also partially enclosed by a considerable mass of earth.

The roof and exterior walls as well as the beams and floor slabs, are of heavily reinforced concrete. Additional bracing against lateral pressures is obtained in some areas by interior transverse concrete walls and by the double-corridor plan which gives the building more than usual depth (Fig. 1). Arguments sometimes raised against the double-corridor plan—inadequate ventilation and lighting in central areas not provided with windows—are not applicable to this building, because all usable space is provided with suitable artificial lighting and air-conditioning. The wall facing the city of Washington is designed to provide twice the strength of the roof and the other three walls. Openings through the blast wall have been kept at the minimum demanded for efficient operation. These openings can be closed by either motor-driven remotely controlled or manually operated blast doors. In line with the protective construction, there are stand-by emergency electric power units with automatic controls and a reserve water supply.

Flexibility of design. The designers realized that all progressive scientific institutions must make frequent future alterations in laboratory facilities for adaptation to new methods and problems; therefore, a modular type of design was selected because it provides the greatest degree of flexibility. Flexibility as used here implies an ability to alter laboratory facilities simply, rapidly, and economically. The module may be considered as a repetitive space- and facilities-unit pattern, or, as applied to investigative laboratories, it may be defined generally as the unit of space and facilities required functionally. This type of design characterizes many outstanding laboratories built in recent years (*3–5*).

The module selected for laboratory areas in the central core is 11 by 20 ft and the one for the office-type spaces in perimeter areas is 11 by 18 ft. Each laboratory module has available the basic piped services of hot and cold water, waste, gas, compressed air, vacuum, and steam. These piped services run from horizontal feed lines in the central service core (Fig. 2). The feed lines are connected to a double set of vertical risers extending in the service core from the subbasement to the top laboratory floor, interconnected and valved for complete flexibility.

The pipes for each module are individually valved, making it possible to effect changes in one laboratory without disturbing operations in adjacent laboratories. Pipes are fastened to floor-mounted vertical steel supports, entirely independent of the steel partitions. The supports are surmounted by a 6-in. strip of laboratory counter with valved outlet fixtures (Fig. 3). Thus movable steel partitions are not marred by holes for bracket pipe supports, permitting reuse in any location without repair or refinishing. The pipes are concealed by movable steel furniture or panel units, which can be moved out from the wall to provide ready access for maintenance or revision. Doors, artificial lighting fixtures, electrical facilities, and air-conditioning ducts generally are provided in a similar manner for each module unit.

Laboratory module areas are separated by standard movable steel partitions and are equipped with movable standard furniture and building fixtures to facilitate interchange of items among varying spaces. The module system also permits easier and less expensive revision of space to serve other than laboratory purposes—for example, changing a chemistry laboratory to an office or a storeroom to a small shop. In all flexible areas, the floor finish and ceilings run through without interruption, so that no breaks will show when partitions are relocated.

Windowless design. Many persons have an instinctive objection to living or working in buildings without windows, and several inquiries concerning this feature of the new AFIP building have been received. It should be pointed out that the directive to design a bomb-resistant structure left no choice but to omit windows. However, several medical and industrial institutions have purposely erected windowless buildings because of their recognized advantages (*3*). For example, valuable space can be more efficiently utilized; lighting and air-conditioning can be more completely controlled; the building is more economical to heat in winter and cool in summer; there is less distraction to workers; and buildings are generally simpler to construct without windows.

The disadvantages of windowless buildings were also appreciated by the AFIP planning group. The hazard posed by possible breakdown in the lighting system is overcome by provision for an automatically controlled emergency power source. More serious is the esthetic objection of some persons to working in a room that has no view of the surrounding landscape. The new AFIP building design incorporates several features expected to combat successfully this prejudice against windowless areas.

For example, complete air-conditioning will prevent the objections sometimes associated with windowless areas in older conventional buildings; lighting intensity and interior color schemes have been planned to compensate insofar as possible for the lack of natural light; emphasis is placed on the use of colors from the "warm" portion of the spectrum; monotony of enclosed corridors is reduced by division into short segments, by variation in color schemes, and by intermittent horizontal illumination from recessed illuminated display cases. Finally, it should be noted that conventional fenestration is not completely lacking. In addition to the windows on three sides of the small north and south wings, there is a large expanse of plate glass in the wall of the snackbar-recreation area overlooking the grounds from a roof deck over the freight platform. A stimulating view of the landscaped grounds will be provided the staff during luncheon and pauses for refreshment.

Lighting and interior finishes. Various light sources were tested in an 11 by 20 ft pilot laboratory module during early stages of planning. Best results were obtained with four 4-ft surface-mounted fixtures each equipped with four 40-w fluorescent tubes. Fluorescent lamps were considered more desirable than incandescent lamps, because they are more economical to operate, provide maximum illumination but minimum load on the air-conditioning system, and furnish a more evenly distributed light. Intensity of illumination at work-bench level is 45 to 50 ft-ca. Office-type areas have an average intensity at desk level of 30 to 35 ft-ca. The lighting fixtures were selected to harmonize with the architectural design, and not only the intensity but also the color temperature of the lighting was carefully considered for specific tasks to be performed.

Corridors are lined with a light yellow glazed-tile wainscot, and they have marbleized light beige-grey asphalt tile floors. Plastered walls above the wainscot are painted a different color on each floor, and the shade of this color changes at points of intersection with elevator lobby walls. Laboratory areas have dark maroon marbleized asphalt tile floors contrasting with light green laboratory furniture

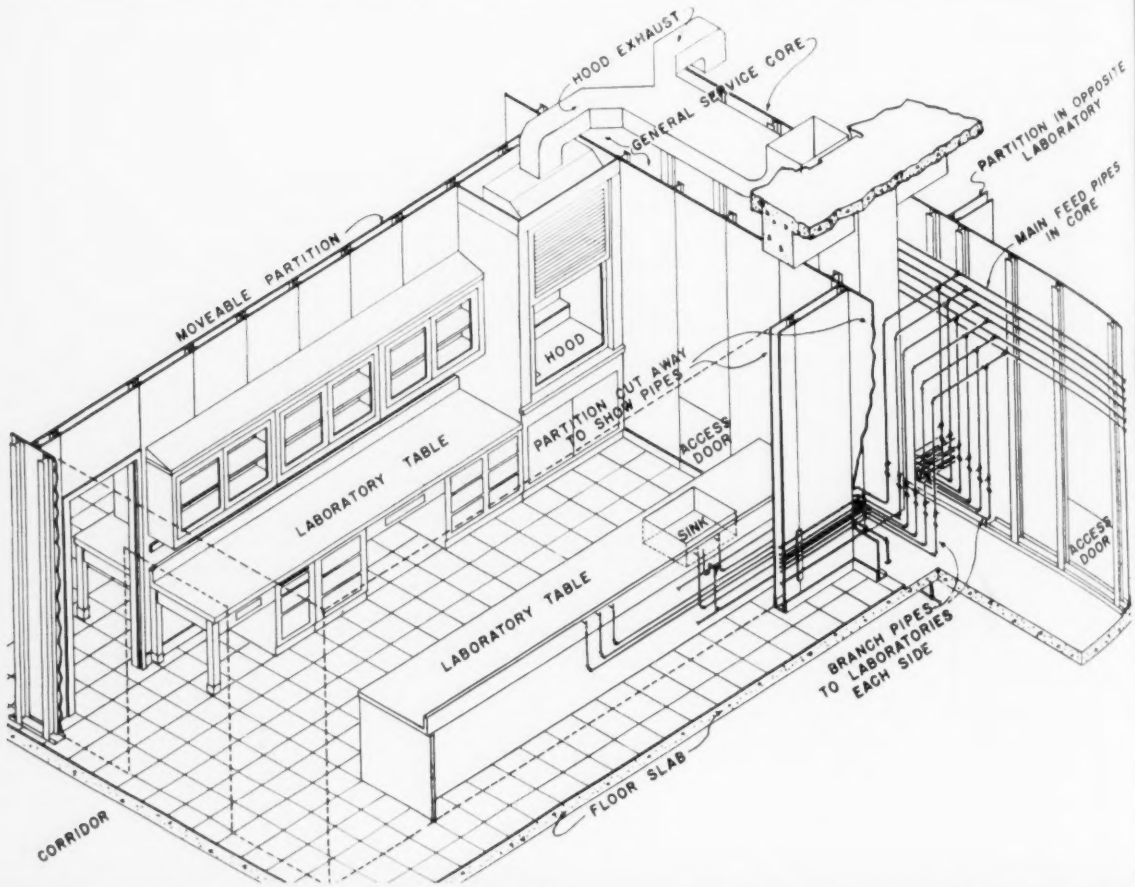


Fig. 2. Isometric drawing of typical module, showing plan for piped services, air exhaust for hood, and arrangement of furniture.

and the lighter green partitions. Rooms with plastered walls are painted in light neutral colors. The walls of the main lobby, the director's board room, library reading room, and auditorium are attractively paneled in walnut. Corridor doors are oak. Hardware throughout the building is white metal. One of the building's most striking centers is the snackbar-recreation area on the first floor (Fig. 1). This room will be furnished in bright warm colors, and the west wall is finished in glazed tile, incorporating an interesting and vigorous abstract design by the architect-engineer.

Elevators. Lobby spaces in the center of the building serve four elevators, comprising two passenger, one service, and one freight elevator (Fig. 1). All have leveling devices and doors that open and close automatically. A fifth elevator serves the morgue. The interiors of elevator cars are bright blue, thus contributing to the stimulating color scheme of the building.

The two passenger elevators have the latest in modern electronic signal controls, and corridor buttons are so integrated that calls are answered by the first elevator to arrive at a particular level. During rush hours attendants usually will be on duty, but the fully automatic design features make it possible to place these elevators under passenger control by the snap of a key switch. Each of these elevators can transport approximately 20 persons (3000 lb) at a speed of 400 ft/min.

The service and freight elevators have individual controls and automatic features to permit operation by either attendants or passengers. The service elevator is designed to transport laboratory supplies and similar items as well as passengers. It has a lifting capacity of 5000 lb at 400 ft/min. The freight elevator will carry 6000 lb at 15 ft/min. The mortuary elevator is equipped with manually operated gate and doors; it has a capacity of 2000 lb and a speed of 25 ft/min.

Air-conditioning systems. The entire building is air-conditioned by systems especially planned as an integral part of the over-all bomb-resistant design. All air is supplied to, or exhausted from, the fan systems through openings protected by bomb-resistant closures. Emergency push buttons at central control points can actuate all motor-driven closures simultaneously upon receipt of an "alert" signal, and all general circulation fan motors are cut off by automatic limit-stop switches. Laboratory hood fans will continue running after the general circulation fans have stopped. These hood booster fans continue to exhaust air from all laboratory hoods until the bomb-resistant shutter is closed sufficiently to stop the booster-fan motors. The shutter is actuated

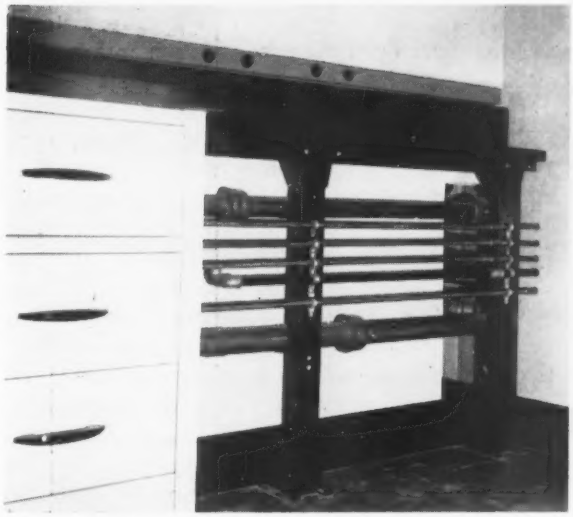


Fig. 3. Pipes on vertical supports along laboratory wall; furniture unit has been moved away; entry to service core is at extreme right.

by air-pressure switches. General aspects of a representative part of this system are shown in a schematic diagram (Fig. 4).

The air-conditioning systems furnish individual supplies of conditioned air to building areas grouped as follows: laboratories, offices, animal holdings, ground floor and basement, subbasement equipment rooms, office wings (north and south), machine shops, snackbar-recreation area, television studio, historadiobiology laboratory hoods. These areas are served by 15 separate supply zones. Incoming air is treated in the subbasement by electrostatic filters, dehumidifiers, and heaters or cooling

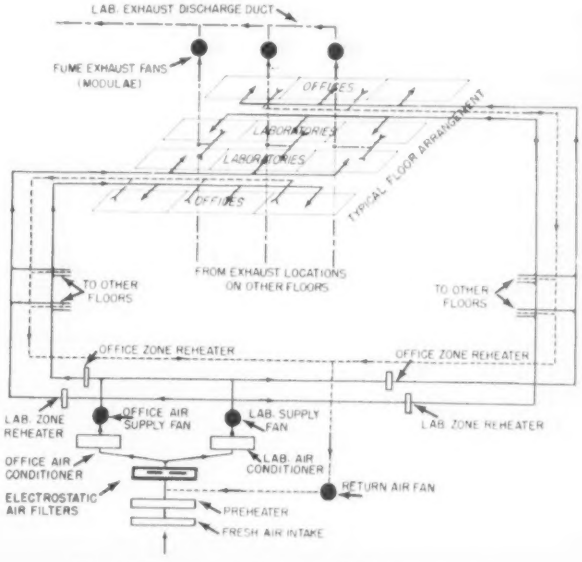


Fig. 4. Diagram of air-conditioning system.

coils. Exhaust fans, comprising 48 separate systems, serve the special exhaust needs of such areas as laboratories with hoods, woodworking and plastics shop rotoclone dust collectors, and projection booths. Fans for the laboratory hoods generally are located in the penthouse fan room.

To protect against the potential hazard of spreading air from laboratories dealing with dangerous biological or radioactive material and to prevent the spread of objectionable odors, air is not recirculated with the exception of a portion of the air from the television studio and certain general office spaces. Prerelease treatment by mechanical filtration or incineration provides additional safety factors in the handling of air exhausted from laboratories dealing with radioactive isotopes or dangerous bacteria and viruses. In conjunction with the 1200-ton refrigeration plant, the condensing water-cooling tower is located at the northeast corner of the building to take advantage of the prevailing southeast summer winds; thus, the warm moist air discharged from the towers will be blown away from the building.

Electric and communications systems. The AFIP planning group was fully cognizant of the phenomenal increase in electric-power consumption during the last several decades. Anticipating a continuation of this trend, detailed studies were made to determine the present (time of occupancy) and future power requirements. The substation and the electric distribution equipment may reasonably be expected to prove adequate for a period of 15 to 20 yr hence.

The electric systems are designed for a winter load of 1500 kva and a summer load of 2800 kva. Various network systems will be supplied by two utility feeders, each rated at 13,800 v. The total transformer capacity is 7000 kva, which provides a 100-percent connected stand-by capacity for the lighting and small-power loads as well as for the heavy-power loads to certain essential mechanical equipment. This capacity will permit the shutdown or failure of a 13,800-v feeder or a main power transformer without affecting the distribution systems. For persons not acquainted with electric systems, the magnitude of the AFIP electric requirements can be better appreciated from the estimate that the building's capacity is approximately that of an "average" town of 5000 persons.

The distribution systems emanate from a substation located centrally in the subbasement (Fig. 5). The main buses rise in a vertical shaft and are designed to provide maximum flexibility for establishing horizontal take-offs to feeder buses on each floor. For each laboratory module, there is an individual multicircuit breaker panel from which power is distributed through a series of wire raceways along the partitions over the laboratory benches. Technicians can thus plug in electric connections at any site along the partitions. Motor-control centers include emergency buses to carry power to all essential equipment in case of failure of the main power supply. A power failure will automatically shift the circuits for emergency lighting and critical mechanical and laboratory equipment to a 175-kw emergency diesel generator, which will start automatically and for an indefinite period supply these circuits. In addition, a 125-v, 330-amp hr, emergency lighting battery is provided; it can sustain this load for 1 hr.

Through electric interlocking connections, the failure of vital equipment is automatically registered by alarms and/or electrically alleviated by placing into operation stand-by equipment. Audible and visual alarms will be activated, for example, in case the ventilating systems for the historadiobiology laboratories fail. Remote control is provided for all essential mechanical equipment. Practically all pumps, fans, and compressors are connected to a control signal and alarm system for the purpose of indicating their operational status.

An extensive under-floor and riser conduit network provides flexible and efficient office intercommunication and telephone and paging facilities. These conduits also contain a system for central sound recording. At a single station, lectures or conferences may be recorded from 11 different areas, including the director's board room, auditorium, two classrooms, conference rooms, and autopsy suite. Knee-control switches will enable pathologists to use this system during autopsy examinations. The system includes wall-mounted speakers installed in assembly areas to make previously recorded lectures or other material available to students or staff assemblies. Console stations located at the rear of the auditorium and teaching laboratory are equipped so that the operator can control the lighting, monitor the recording signal, adjust the screen, and communicate with the central recording station, the lecturer, the projectionist, and the television staff.

Separate conduits carry the fire-alarm and television cables. The television studio is equipped with the most modern electric controls and operating switchboard, thus permitting the transmission of color television. Clocks are connected to the general lighting system and are synchronized by high-frequency impulses from master clocks. Thus the clocks and clock impulses, as well as the lighting fixtures, are simultaneously supplied electric current at different frequencies over the common lighting

circuits. Clocks throughout the building can be correctly timed from a single master clock.

Steam for air-conditioning heating coils, hot water, and laboratory use will be conducted from a central heating plant at a pressure of 100 lb/in.^{2} and reduced in the building to the pressures required for specific purposes. Water-supply and sewage-disposal systems are connected to existing city systems. Drainage pipes from laboratory sinks are high-silicon-content cast iron. Drainage from the historadiobiology laboratory passes to sewers through a separate system, designed for future incorporation of radioactive isotope decay-holding tanks and for the addition of a continuous monitoring device with automatic recording attachment.

Distilled water is readily available to all laboratories. These recessed cabinets in the corridors of each floor are located in the quadrants of the building. The cabinets are supplied by stainless steel piping from a 300-gal storage tank in the fan room. Chilled water is piped to individual photographic laboratories and drinking fountains from a separate refrigeration system. Emergency deluge showers are located strategically in corridors outside doors to laboratory modules.

The piped services for laboratory modules are described under "Flexibility of design."

Arrangement of Facilities and Space Assignments

Central locations are provided for the executive and related administrative offices, auditorium, rooms for consultants and special students, library, teaching laboratories, and snackbar-recreation area. Pathological specimens, related records, and illustrative material are on underground floors. Investigative laboratories, animal-holding rooms, and the incinerator are on the upper floors in order to minimize expensive ducts exhausting air from these areas to the vents above the roof.

Stairs are located centrally and at each end of the building. Full advantage was taken of a sloping terrain by providing the main entry for staff and visitors on the west side of the building at the first floor, and in locating the service and shipping entrance on the opposite side of the building on the floor below. Doors, ramps, and sidewalks at the north and south ends of the building permit access to the parking areas without going through the main entrance.

Specific location, by floors. Subbasement: mechanical equipment (air-conditioning, electric); wet-tissue files; and autopsy and preparation rooms.

Basement: medical illustration service, comprising the photography division, visual-aids branch, photostat and printing facilities; atlas of tumor pathology offices; medical museum laboratories; classroom I; professional services office, comprising the professional records branch, diagnostic index coding branch, statistics and follow-up branch, machine records branch.

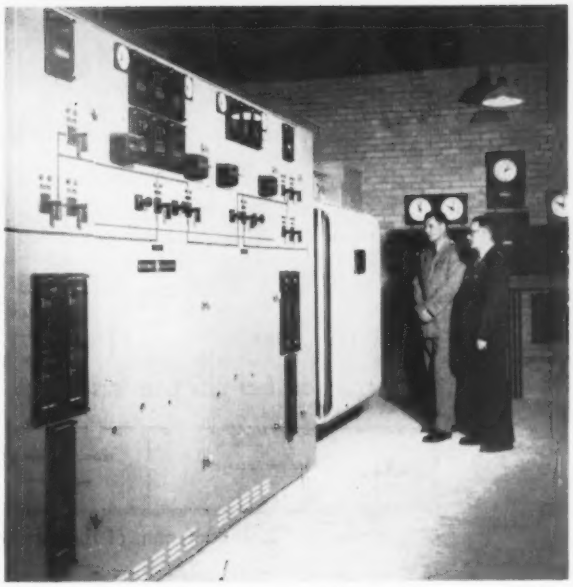


Fig. 5. Part of substation area; 120- to 208-v distribution switch gear.

Ground floor: receiving and accessions branch; mail and message center; medical supply; television-motion picture studio; medical illustration service, comprising chief and administrative staff, shops and scientific illustration division, illustration library.

First floor: the director's and administrative offices; chief of department of pathology; pathologists' offices and individual laboratories; auditorium; snackbar-recreation area; curator of medical museum; consultants and special students' rooms.

Second floor: pathology department, Walter Reed Army Hospital; histopathology laboratories; classroom II; teaching museum; pathologists' offices and individual laboratories; overnight facilities for staff investigators.

Third floor: American Registry of Pathology; histochemistry laboratories; cytophysics laboratories; teaching laboratory and special students' rooms.

Fourth floor: histobacteriology and virus laboratories; historadiobiology laboratories; tissue-culture laboratories; central laboratory facilities and supply; library; editorial branch.

Fifth floor: animal-holding rooms; animal-cage washing facilities; animal x-ray, surgery, and autopsy suite.

Typical floor plan. The double-corridor plan for

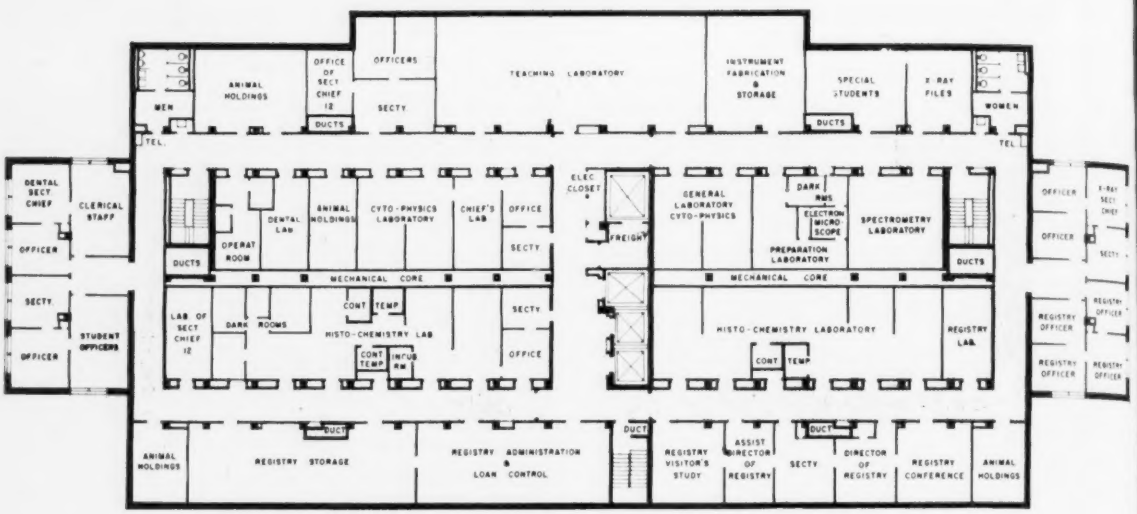


Fig. 6. Third-floor plan of the Armed Forces Institute of Pathology building.

typical floors is illustrated in Figs. 1 and 6. In this scheme, the long axes of laboratory modules are perpendicular and adjacent to the single continuous mechanical service core that rises through the building on its longitudinal center line. This layout provides the desired flexibility and results in a saving of space and a reduction in construction and maintenance costs.

Typical laboratories. Most of the one-module laboratories have laboratory furniture extending along the two 20-ft partitions (Fig. 7). Laboratory counters along one partition are "stand-up height" (37 in. from the floor) and include the sink unit. Along the other partition, the counters are "sit-down height" (31 in. from the floor) and include a built-in desk unit near the door.

Albarene stone is used for most laboratory sinks, and this material or synthetic stone is used for counters in most of the chemistry-type laboratories. Birch counter tops with black acid-resistant finish are used in the majority of general-purpose laboratories. Stainless steel counters are installed in several rooms designed for work with radioactive isotopes or dangerous living organisms.

Hoods are installed in selected laboratories and replace a standard laboratory counter unit adjacent to the central service core. This typical hood location was chosen to minimize the length of ducts exhausting air and to eliminate the possibility of a laboratory worker being blocked from exit by fires or explosions occurring in the hood. Cabinets with sliding glazed doors are wall-mounted above the laboratory counters, except in areas where the installation would interfere with counter-mounted apparatus.

The applicability of the module system to laboratories for multiple workers or for installation of special equipment is illustrated by the drawing of the third floor (Fig. 6). Within the cytophysics laboratory area, demountable partitions are utilized in adapting a two-module space to the requirements of the electron-microscopy facilities. Also illustrated is an arrangement of the use of a two-module space to provide four demountable controlled-temperature rooms within the histochemistry laboratory area.

Closed-Circuit Color Television System

The AFIP staff believes that color television will prove increasingly valuable in medical teaching and investigative programs. The design of the new building incorporates a modest initial closed-circuit color television installation that can be expanded economically and efficiently as the staff gains experience and as improved equipment becomes available. Establishment of color television communication between buildings in the immediate vicinity, throughout the Washington area, and even with distant cities is anticipated.

The television studio with a two-story ceiling height occupies the entire wing at the southeast corner of the building (Fig. 1). Conduits have been installed to link the studio control rooms with multiple points throughout the building. As knowledge is gained and funds become available, it is planned to establish permanent color television camera stations in the studio, the autopsy suite, and in the surgical pathology laboratory of Walter Reed Army Hospital. This hospital facility will be located in the AFIP building. Table- or cabinet-type television receivers will be installed in various classrooms and conference rooms. Installation of large-screen tele-

vision projectors in the auditorium and the large teaching laboratory is planned.

The extensive conduit system for coaxial cables makes possible the future utilization of portable "plug-in" cameras and receivers in many offices and private laboratories on all floors.

Facilities for recording televised programs on film will be installed in the studio control rooms. These films will constitute a valuable source of teaching material for the AFIP staff and for numerous field installations. The equipment will include facilities for projecting, as an integral part of the AFIP presentations, varied motion-picture films and kinescope recordings prepared elsewhere.

By means of a color television circuit planned between the surgical pathology laboratory and the operating rooms of Walter Reed Army Hospital, the pathologist will be able to observe and talk with the surgeon during an operation. The surgical staff will be able to view the gross and microscopic aspects of the surgical specimen being considered and discuss it with the pathologist. To supplement this television circuit, there is a pneumatic-tube system that can speedily deliver specimens from the operating room to the pathology laboratory, approximately three blocks away.

The existing obsolete building has long imposed three severe handicaps on the steadily expanding AFIP as its staff has been faced with increasing workload and responsibilities. These handicaps have been inadequate space, lack of flexibility, and complete absence of experimental facilities. The new building is designed to alleviate these handicaps. The designers are confident that the staff will be able to conduct future operations effectively in the stimulating and pleasant environment.

The need for future expansion was considered at all stages of planning. For example, the location of the building allows space for future wings at both the north and south ends of the building.

Many interesting observations were made during the planning of these facilities. For other medical professional personnel faced with planning complex medical buildings without benefit of previous experience, it is strongly recommended that the active planning be preceded by the most careful preliminary studies of the basic functional requirements and that conferences be arranged with others who have developed similar projects. It is considered particularly important that the medical staff cooperate wholeheartedly in team fashion with the architects and engineers who should be invited to participate most intimately in all phases of the studies. Medical specialists will often be amazed at the ability of architects and engineers to analyze activities in medical institutions and to make fundamental recommendations for improving the efficiency and economy of basic operations.

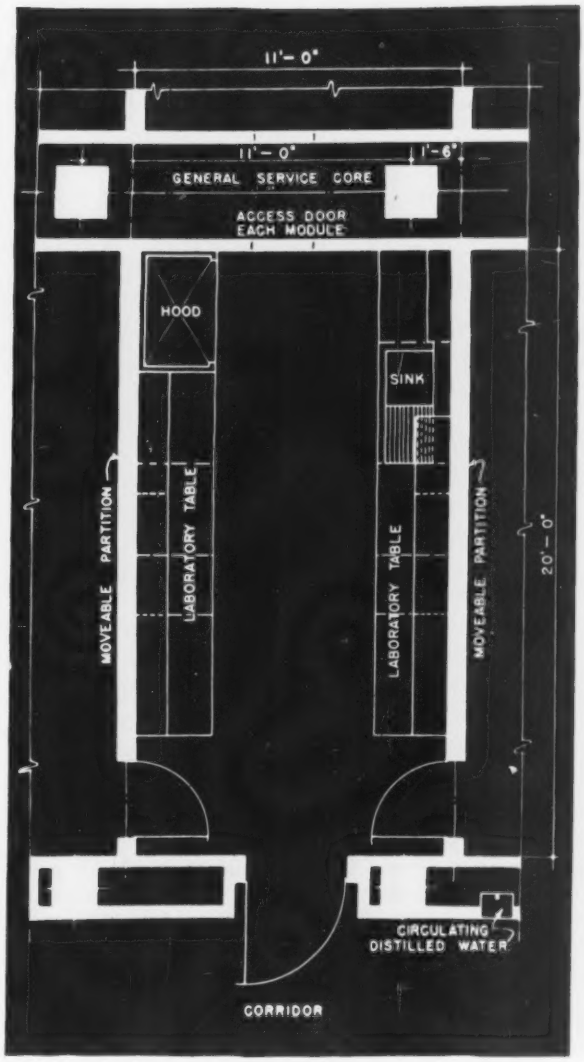


Fig. 7. Plan of typical laboratory module.

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Views on the Amazon Valley

F. A. CARLSON

The author is professor of geography at The Ohio State University. He received his B.S. degree from the University of Massachusetts and his Ph.D. degree from Cornell University. Dr. Carlson is interested primarily in the geography of the American humid tropics, having carried on fieldwork in the West Indies and South America. In 1953, through a grant from The Ohio State University Research Foundation, he made an exploratory survey of selected areas in the Amazon region. He has contributed a number of publications on the other Americas.

WITHIN the Amazon region, an area of more than twice the size of the Mississippi Valley, is the world's largest tropical rainforest, or selva. Here is the "Mighty Amazon" with its innumerable tributaries. From the confluence of the headstreams Marañón and Ucayali in eastern Peru, the Amazon River flows for some 2400 mi to the Atlantic Ocean. In places it meanders through jungles in a single channel, but, for the most part, it is an intricate network of streams, associated with sloughs, lakes, islands, and marshes.

During the periodic floods, vast areas are inundated. The description "Inland Sea" is not an exaggeration. Generally, the time of high water coincides with the season of maximum rainfall, November to June. In the region of Iquitos, Peru, the flood crest is reached in May; in the area of Manaus, Brazil, the high-water level is in June; and in the lower Amazon, in the vicinity of Belém, Brazil, the first sign of high water appears in October, and the river continues to rise until April. The ebb stage is between May and September.

Unprecedented floods occurred in 1953, particularly in the area where the Rio Negro empties into the Amazon River, causing considerable loss of livestock, crops, and property. There was a great deal of suffering on the part of the poor people who have their huts on the river banks. An unforgettable sight during the 6000 mi of travel in the Amazon region was a view from a Catalina plane or river flying boat at an altitude of 1000 ft. The surface was an intricate pattern of forests and savannas, a mosaic of greens and yellow; an amazing expanse of flood water; tops of partially inundated clusters of palm-thatched roof huts; rafts on which cattle and hogs had been corralled; and ocean-going vessels and dugout canoes plying the uncontrolled waters of the Amazon.

The rise and fall of the Amazon River has considerable bearing on the regional activities. Floating docks are necessary in some places. At the port of Manaus, 1000 mi from the Atlantic Ocean and accessible to ocean freighters, the largest floating dock in the Western Hemisphere, and perhaps in the world, has been constructed to accommodate a 60-ft rise and fall of the water. Rubber-tree tapping is limited in many areas to the period of low water. Generally, logging is confined to the season of minimum rainfall, and then during the period of floods the log rafts are floated downstream to the lumber mills. The flood plains are the chosen sites for the cultivation of manioc, rice, beans, corn, jute, and other crops. In fertility, the recent alluvial soils are far superior to the generally poor upland soils, the latter probably classified as latosols.

While field observations were limited primarily to areas along the rivers, there was some opportunity to note conditions beyond the immediate river banks. It was apparent that tropical rainforests occur on both the uplands and flood plains. However, the flora of each may be quite different, owing to what appeared to be drainage conditions. Along the rivers, a surprising amount of deforestation has taken place, obviously the result of 100 yr or more of exploitation to supply fuel for river steamers, electric plants, and homes, to clear the land for agriculture, and to supply timber for sawmills. In the areas where a second growth of vegetation has taken place, the true tropical jungles persist, an interwoven mass of trees, vines, bushes, and ferns. The virgin forest consists of tall trees with few branches and spreading crowns with bromeliads and lianas, forming nearly a complete canopy. However, contrary to expectations, the damp floor of the selva was not free of a dense undergrowth of bushes and ferns, even though only a dim light penetrated the overhead vegetation. It has been reported that there are more than 2500 species of trees in the Amazon region and as many

Fig. 1. Port of Manaus. Oceangoing vessels call at Manaus, 1000 mi from the Atlantic Ocean.

as 150 species of trees to an acre (*1*). Probably the most majestic of all is the Ceiba, called the "Queen of the Amazon Forest." It is a tall tree with a large trunk with buttress-like ridges. In season it bears pods containing a fiber known as kapok (*2*).

Among the trees of outstanding commercial importance is the Castanha or brazil nut tree. It grows to a height of 150 ft with few branches except in its crown which is often as much as 100 ft in diameter while the base of the trunk is from 2 to 4 ft in diameter. The average yield per tree may exceed 500 lb of nuts. It has been estimated that more than 165,000 Castanha trees in the Amazon region are harvested with an annual production of about 30,000 tons of nuts. The leading markets for shelled and unshelled brazil nuts are the United States, United Kingdom, Canada, and Germany.

Of course, the "Tree of Trees," the very symbol of the Amazon Valley, is the *Hevea* (*3*). It also is a big tree, 80 to 100 ft high with a trunk some 3 to 4 ft in diameter. Although *Hevea* is distributed throughout much of the Amazon region, one rarely finds more than three or four rubber trees per acre. The total yearly yield of wild rubber in the area is approximately 30,000 tons, which compares favorably with 45,000 tons during the Amazon rubber boom in 1910 and 1912.

According to Brazilian reports, the number of cultivated rubber trees exceeds 3 million, and most of these are on the Belterra plantation. When the Ford Motor Company rubber plantation projects at Fordlandia and Belterra in the Rio Tapajós Valley were turned over to the state of Pará after some 20 yr of unsuccessful attempts to grow rubber trees, Fordlandia was converted into a general experimental farm but Belterra was continued as a rubber plantation research center. The diseases that attacked the leaves and roots of the rubber trees have been largely overcome as a result of the research of the Institúto Agronômica do Norte, a tropical agricultural experiment station, located some 5 mi from Belém. The failure of the former Ford projects in the Amazon region was in part due to plant diseases.

The continued interest in the expansion of Amazon rubber plantations is attributed not only to the research of the Agronomic Institute but also to the activities of the Bańco de Crédito da Amazónia, S. A. The bank was organized as a result of the Brazilian-United States Rubber Agreement of 1942. This organization aims to carry on banking operations related directly or indirectly to industrial, commercial, and other production activities of the Brazilian Amazon region, principally those concerning the trade and industrialization of rubber. It assists financially any planting and producing operations promoted by private planters and producers of rubber, maintaining complete control and fiscalization of these operations. No exportation of rubber can be made by private producers, since the bank is the only channel for exportation of this product. All rubber produced has to be sold to the bank, which controls selling operations. It is interesting to note that the distribution of the number of shareholders of the Amazon Credit Bank is approximately as follows: Brazilian Federal Government,

59 percent; United States Government (Reconstruction Finance Corporation), 40 percent; and private, 1 percent.

Practically the entire output of rubber in the Amazon region is shipped to the industrial area of southeastern Brazil. However, with the increasing consumption of rubber in Brazil from an estimated 3000 tons in 1939 to 40,000 tons in 1953, the nation may have to import more foreign rubber unless there is an increase in its domestic production. Although efforts are being made to expand the Amazonian rubber culture, it is not likely that plantations will be a significant source of rubber for many years to come. The problem of rubber supply may be solved, at least temporarily, through a greater utilization of wild rubber. It has been reported that production of the Amazon forest rubber can be increased from its present output of 30,000 tons to 45,000 tons. This may call for a continuation or even an increase in the present Brazilian price-support of domestic rubber. In 1953, the price of rubber latex produced in the Belterra region was about 70 ct/lb as compared with some 25 ct for rubber on the free market.

A greater and a more efficient use of the forests is high on the list of plans for future development of the Amazon region. Among the existing problems are distances and inadequate transportation facilities to consumer markets, the need for logging roads, obsolete equipment and mill operations, a clarification of standards and classes of woods, the use of by-products, and capital. One of the few modern mills is located at the confluence of the Nanay and Amazon rivers in eastern Peru, known as the Astoria Lumber Company. The plant is well equipped and under efficient management. It specializes in the milling of mahogany and cedar lumber. Most of the mahogany logs are floated down the Pachitea and Ucayali rivers to the Astoria mills, a distance of 700 mi. Mahogany grows best on well-drained upland areas, while the cedar comes primarily from the lowlands along the Ucayali River. The trees are felled and crosscut into logs during the dry season, and then in the flood period the logs are rafted and floated downstream to the mills. Most of the Astoria mahogany lumber is exported to the United States, while the cedar is shipped to Lima, Peru, via the Amazon River and the Panama Canal in Peruvian National Steamers, a distance of some 6000 mi. The long haul means high transportation costs, which add to the difficulty in competing in foreign markets with other producers who enjoy a more favorable location.

A new prospective adventure in the use of forest resources of the Amazon region is the production of wood pulp. Plans call for the construction of pulp factories, one on the island of Marajó, a second near the mouth of the Madeira River, and a third in the vicinity of Manaus. A pulp industry in the tropics would permit year-round operation, an advantage over the seasonal activity of some of the northern plants.

TABLE 1. Climatic Data for Bélem, Santarém, Manaus, and Iquitos.

	Rainfall (in.)				Temperature (°F)							
					Belém		Santarém		Manaus		Iquitos	
	Belém	Santarém	Manaus	Iquitos	Mean Max.	Mean Min.	Mean Max.	Mean Min.	Mean Max.	Mean Min.	Mean Max.	Mean Min.
Jan.	9.2	8.2	9.8	9.2	86.4	72.1	83.1	72.8	88.2	74.7	89.0	70.9
Feb.	13.6	12.1	9.2	13.8	85.6	72.2	82.6	72.0	88.4	74.7	88.5	71.2
Mar.	17.3	12.8	9.8	11.9	85.9	72.5	83.1	72.5	87.6	74.7	89.6	71.5
Apr.	16.7	12.5	8.6	9.0	86.9	73.0	83.3	72.5	87.4	74.8	88.0	71.4
May	11.7	9.9	7.0	7.7	87.8	72.9	83.5	72.3	87.8	74.9	88.5	71.4
June	9.1	5.5	3.8	6.6	88.1	71.9	84.9	71.4	88.1	74.8	87.3	70.1
July	3.1	2.8	2.3	5.4	88.1	71.4	86.2	70.3	89.1	74.5	88.4	69.4
Aug.	3.0	1.5	1.4	5.5	88.1	71.4	88.9	71.1	90.9	74.9	90.2	69.4
Sept.	1.8	1.1	2.0	4.5	88.5	71.0	89.8	72.1	92.3	75.0	91.3	70.2
Oct.	3.3	2.0	4.1	8.3	89.0	71.1	90.3	72.7	91.9	75.8	92.4	71.4
Nov.	1.1	2.6	6.1	6.8	89.4	71.4	90.1	72.9	91.3	75.7	92.0	72.3
Dec.	4.2	4.7	7.8	7.5	88.4	72.0	87.1	72.5	89.7	75.0	90.3	72.0
Year	94.1	75.7	71.9	96.2	87.7	71.9	86.1	72.0	89.4	75.0	89.6	70.9
Period of record	1912 1914	1914–1918 1934–1940	1902–1941	1950–1952	(1895) (1941) (12 yr)		1914–1919		1910–1941		1950–1952	

Another industry based on a forest resource is the production of rosewood oil. It is a distillate, containing a fixative used in the preparation of perfume. Also in the Amazon region there are plants that prepare for exportation gums, known as *Leche Caspi* or *Leite de sorva, Leite de Maçaranduba, Ucuquirana,* and others.

Although the economy of the Amazon Valley is still largely dependent upon raw materials, the trend is definitely toward a greater degree of plantation culture as well as the processing of the commodities before they are exported. In this respect, it was particularly interesting to note the culture of jute and black pepper. Both of these crops were introduced into the Amazon area from Asia by Japanese immigrants who came into the region 20 yr ago. It is rather singular that the Amazon Valley provided Asia with its initial rubber industry, the *Hevea brasiliensis* being indigenous to the Amazon Valley, and now Asia has somewhat reciprocated in terms of jute and black pepper.

Jute culture continues to be carried on almost entirely by the labor of Brazilians of Japanese descent or Japanese immigrants. It is only a part-time job and is most disagreeable, particularly the retting process in which workers must wade waist deep in river water while treading the jute stalks.

To grow jute, the seeds are planted in the flood plains at the beginning of the rainy season. After about 4 mo when the jute is in flower, the fiber is at its best. It is then cut by hand and hauled to a creek or pond where it can be immersed and soaked for 8 to 10 days. During this period, the cambium layer decomposes and the fibrous bark then slips easily from the stalk. After the fiber is stripped from the stalk, it is washed and hung up to air dry. It is later bagged for shipment.

Seed is furnished free to the jute planters by the Agronomic Institute. Jute production has increased from 9 tons in 1936 to some 40,000 tons in 1953, with an all-time high of 50,000 tons in 1951. Producers claim that within the next 2 or 3 yr jute will be available in quantities sufficient for Brazil's needs and also to permit its export to foreign markets. A jute mill, the first in the Amazon region, is nearing completion in Manaus, with a capacity to handle 10 tons of jute daily. The output will be used in the Manaus area for bagging brazil nuts, alligator skins, dried fish, and other local products. A second jute factory of about the same capacity as the Manaus plant is under construction in Santarém.

Black pepper is the second crop, jute being the first, from the Far East of economic value that is successfully developed in the Amazon region. While the production of black pepper in Brazil is far below its domestic requirements, the Amazon planters, mostly of Japanese heritage, are making serious effort to increase their plantations to make the Amazon region an important source of black pepper. It is said that Amazon black pepper is preferred over other pepper by Brazilian canned-food and sausage factories because it contains a high percentage of piperine.

One of the urgent needs in the Amazon Valley is an adequate production of food crops. At present, a major portion of essential items, such as rice and beans, is imported from southeastern Brazil. If this problem continues, it will become more serious as the population of the valley increases, and it is apparent that efforts are being made to encourage greater immigration, particularly from northeastern Brazil. Some maintain that the number-one problem in the Amazon area is its sparsity of population. Probably it is not so much a lack of numbers of Amazonians as it is a problem of a more active participation in regional affairs on the part of some of the river folks, particularly the inhabitants of Indian heritage.

Agronomists appear to agree that the humid tropical soils in upland areas after two or three crops are low in plant nutrients, owing to the high rate of humification, leaching, and eluviation. These infertile mature soils, probably latosols, are generally porous, high in oxides of iron, aluminum, and manganese, and low in organic matter. Unfortunately, in the past, these were the soil areas that were most extensively cultivated in the Amazon Valley. Whereas in the lowlands, the present more desired agricultural areas, the periodic floods replenish the essential plant elements and, thus, the soils support yearly crops without the addition of chemical fertilizers. Here are the possible future sites of the much needed food crops of the Amazon region, particularly rice, beans, manioc, and green vegetables.

Owing to federal restrictions and limited fieldwork, comparatively little information is available on the mineral resources of the Amazon Valley. In the Upper Amazon area, in eastern Peru, there are a number of oil-producing wells, and a small refinery is located at Aguas Calientes. Much of the crude and refined petroleum used in Iquitos, Peru, and Manaus, Brazil, comes from this Upper Amazon area. In 1953, the first shipment of manganese ore, about 800 tons, was made from the Amazon port of Itaquatiara. It may be the beginning of a new adventure in one of the world's largest underdeveloped regions.

Generally, the visitor's first impression of the

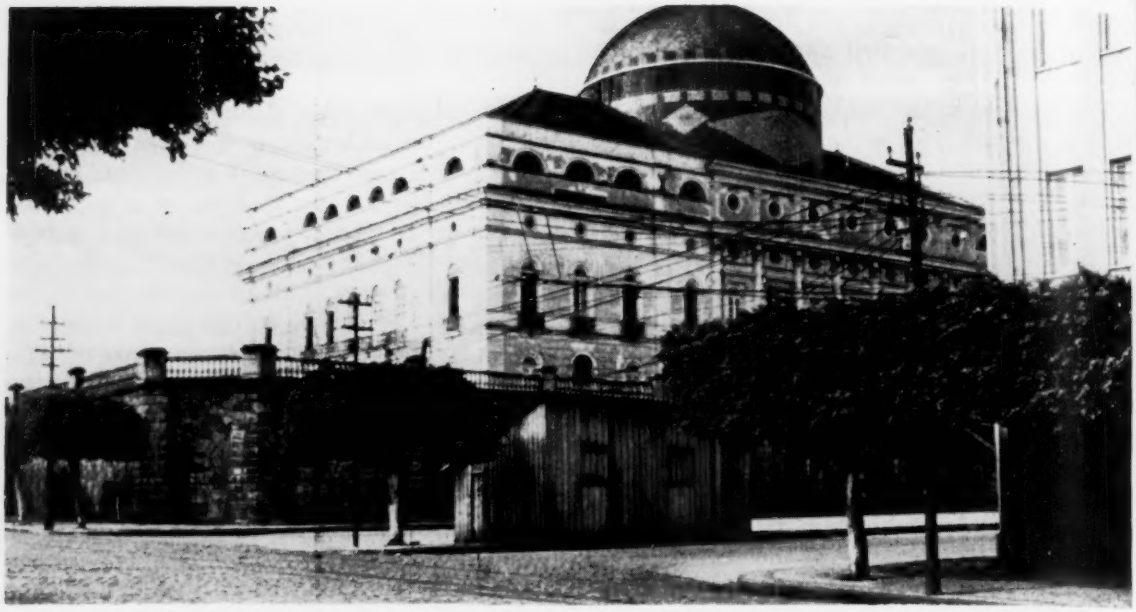

Fig. 2. The "Golden Crowned Opera House" in Manaus. Evidences of the past Amazonian rubber boom.

Amazon Valley centers upon the vastness of the area, the wide expanse of forests, the labyrinth of water, and the nature of the economy. But in the course of time, during which there has been an opportunity for more detailed observations and deliberation, attention is more likely to center on the human element. Probably less is known today about the social problems of the region than about the economic problems. In fact, the total population has been estimated within the wide range of 2 to 3 million, with some 261,000 in Belém, 25,000 in Santarém, 143,000 in Manaus, and 60,000 in Iquitos. These ports are the only urban centers in the entire Amazon Valley. Of course, there are many small towns and villages along the rivers. The degree of modernization varies from the conditions in Belém and Manaus, each with at least one good hotel, fair transportation facilities, excellent parks, interesting shops, and imposing municipal, state, and federal buildings, to the very primitive Indian villages, such as Berlín on the Itaya River in the Upper Amazon Valley. A common need in all the settlements is safe drinking water and proper sanitation.

A typical river village consists of a few wooden buildings and clusters of palm-thatched-roof huts supported on poles. From these settlements come the rubber-tree tappers, gatherers of brazil nuts, logging crews, port laborers, and others whose livelihood depends primarily on fishing, hunting, trading, and a crude form of agriculture and horticulture.

The diet of these river folks consists primarily of starchy foods, including plantains, bananas, manioc or *yuca,* and palm nuts. Fish, particularly dried fish, is the main source of meat. One of the common sights are slabs of fish, known as *pirarucú* in Brazil and as *paiche* in Peru, hanging on sticks to dry in the sun. Game is scarce, although it is eaten when attainable. Most of the game is of the rodent family. Rice is a rare treat and is generally reserved for special occasions. The *yuca* is boiled and served cold; however, the more common use is to prepare the meal, *farinha* or farina, and save it for the flood season when there is little other produce available. Some coffee is used, although in the morning a hot drink made from orange or lemon leaves or lemon grass and sweetened with cane juice may be prepared. An intoxicating drink, known in the Amazon Valley as *masato* or *nijimanche*, is prepared from the fermentation of *yuca.*

The economy is based on a barter system. Few of the river folks ever go to the cities or large towns, depending primarily on peddlers traveling in small boats who exchange drygoods, hardware, and trinkets for chickens, eggs, pigs, rubber, and animal skins. Little cash circulates among the small river settlements, and many of the people will not accept it for their products, preferring something that they can use in exchange.

In the final analysis, it becomes apparent that one of the major forces contributing to the development of the Amazon Valley is the action on the part of each of the Amazon nations, particularly Brazil and Peru. It is quite apparent that the federal leaders recognize the increasing need for a closer

integration of the potentials of the Amazon Valley into their national economy. Evidences of this realization are found in improvements through federal aid, including technical assistance from the United States. Some of these improvements are better transportation facilities, the construction of hotels, the extension of agricultural assistance, the increase in the production of and the utilization of natural resources, and the support of colonization and immigration projects. For example, an overland route extends between the Pacific port of Callao, Peru, and the river port of Pucallpa, the head of river navigation on the Amazon tributary Ucayali in eastern Peru. From Pucallpa, a town of 12,000 inhabitants, wood-burning steamers provide transportation to Iquitos. There is also airplane service between Iquitos and the coastal cities of Peru. The flight time is about 3 hr. A modern Hotel de Turistas has been constructed by the Peruvian Government at Iquitos to encourage travel to the Amazon region. Plans have been made to establish a colony of new settlers in the Pucallpa area. The operation of an agricultural experiment station at Tingo Maria under joint agreement by the Peruvian Government and the United States is further evidence of federal interest in the development of the Upper Amazon region.

In like manner, the Brazilian Government is actively engaged in promoting economic and social projects in its portion of the Amazon region. The establishment of three new territories in 1946 in the Amazon area was in accord with the national policy to direct greater action in its undeveloped regions. Thus, at present, the political divisions of the Brazilian Amazon region are the states of Pará and Amazonas and the territories of Amapá, Rio Branco, Acre, and Guaporé. Transportation is also receiving special attention. The S.N.A.P.P., the Navigation Service of the Amazon and Administration of the port of Pará (Belem), a branch of the Ministry of Transportation and Public Works which operates the Brazilian river transportation system, has announced that it is going to replace some of the obsolete vessels by new combination passenger-cargo carriers as well as improve the over-all river service, a much needed action. Reference has already been made to the support of economic affairs in the valley on the part of the Amazon Credit Bank and the Agronomic Institute. Also, in 1953, the Brazilian National Congress decreed a law entitled "Plan for Rehabilitation of the Amazon Basin," which includes provisions for the financial support of improvement in transportation, public health, education, public utilities, and agriculture. Immigration will be encouraged through loans and land grants. This plan is in accordance with the 1946 Constitution of the United States of Brazil which, in part, reads, "In carrying out the plan for valorizing the economy of the Amazonia the Federal Government will apply for at least twenty years an amount of not less then three per cent of its revenue. . . ." Owing to the failure of the congressional committee to produce an acceptable plan for the expenditure of the 3-percent appropriation of the national revenue, the plan has not been put into effect. However, progress is being made and it is quite likely that it will be activated in 1954.

Fig. 3. Port of Belém. Its annual shipments total more than 350,000 tons of imports and 170,000 tons of exports.

Further evidence of the growing national interest in the Amazon Valley is found in the origin and destination of its exterior trade. A decade ago, 80 percent of the Brazilian Amazon exports were destined for the United States and Europe, but today only some 30 percent of the exports go to foreign markets. In like manner, the Amazon imports come primarily from other regions of Brazil. The imports consist primarily of consumer goods, whereas the exports are chiefly raw materials, such as rubber, brazil nuts, jute fiber, hides and skins, lumber, rosewood oil, dried fish, and gums.

Diverse opinions have been expressed concerning the potentiality of the Amazon Valley, varying from the description "a land of El Dorado" to one of "steaming jungle waste." Both views are undoubtedly incorrect. However, any reference to the future development of the Amazon Valley is weakened by the paucity of information on its physical and cultural features. However, research in the valley has gone far enough to support the statement that

it is not a region of uniformity. Striking contrasts in weather, land, soils, forests, and human culture are in evidence. Further investigation, field studies, and experimentation are necessary, not only to determine more fully the nature of the valley's physical and human features, but also to find the best way to utilize its resources and to develop and to maintain a healthy Amazon society

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2. S. J. Record and R. W. Hess, *Timbers of the New World* (Yale Univ. Press, New Haven, 1943), p. 93.
3. ———, *Ibid.*, p. 159. "There are 12 species in the Amazon Basin. The tree producing the most and best latex and the only species cultivated in plantations is *Hevea brasiliensis.*"

Armed Forces Institute of Pathology Building and Seal

It is no accident that the motif of the seal of the Armed Forces Institute of Pathology in Washington, D.C.—shown on the front cover—is a microscope. This instrument is the basic tool of histopathology, the major activity of the AFIP. The microscope is also symbolic of one of the great national treasures housed in the Medical Museum of the AFIP, for its collection of more than 500 antique and modern microscopes is the largest and most comprehensive in the United States and perhaps in the world. Most of the instruments, chronologically arranged, are on display in the Medical Museum, although some of the more modern research instruments are used regularly by the pathologists who staff the Institute. The seal is embedded in concrete in the entrance to the new AFIP building, which is shown in the lower part of the cover.

Attitudes of Students toward Government Employment

The Federal Government needs a strong recruitment program if it is to attract sufficient scientific talent to meet manpower needs and even then it may be difficult to induce college graduates to enter Government employment, according to a study made by Lowell H. Hattery and Charles M. Hersh of American University, of the attitudes of senior students, faculty, and placement officers in five colleges and universities [*Science* **120**, 12 (2 July 1954)]. The study was conducted in the spring of 1952; institutions studied include Johns Hopkins University, Oberlin College, Purdue University, Syracuse University, and West Virginia University.

Although 38 percent of the 660 seniors questioned had already accepted jobs in late April and early May when the study was made, only 5.2 percent of these had chosen Federal employment. Three out of four had taken jobs in industry.

At one institution, 45 students had been signed up for jobs. Of these, none had chosen Federal employment. At another, six students among 46 who had definitely accepted jobs chose Federal employment.

Science majors were the least likely of the students studied to go into Government employment. About 4 percent of science majors, 5 percent of engineering majors, and 14 percent of social science majors picked Government jobs.

Dust Explosions in Coal Mines and Industry

IRVING HARTMANN

Dr. Hartmann is chief of the Dust Explosions and Coal Mine Experiments Branch, U.S. Bureau of Mines, Pittsburgh, Pennsylvania. He has conducted extensive research on industrial dust explosions, development and control of coal mine explosions, control of mine fires, dust-allaying in mines, safe use of mining explosives, strength and compressibility of coal pillars, effect of temperature and humidity variations on rock strata in mines, and on other mine safety problems. Dr. Hartmann received his training at Cooper Union Institute of Technology, George Washington University, and Catholic University. He is the author of numerous publications related to his research.

IN finely divided form, nearly every combustible solid can, under suitable conditions, produce a dust explosion. The explosion is essentially a rapid combustion, during which flame spreads through the dust cloud and heat is produced more rapidly than it is dissipated to the surroundings. Most explosions are characterized by high flame speeds and high pressures that frequently cause great destruction. In some explosions, the pressure is produced entirely by the heating and expansion of air or other gases in the explosion space; in others, the pressure rise results partly from this cause and partly from the generation of new gases during the combustion. At the high temperatures prevailing in some explosions, endothermic chemical dissociation (which requires heat) of carbon dioxide or water vapor limits pressure development.

The conditions necessary for an explosion are a proper concentration of dust dispersed into a cloud, an adequate supply of air or oxygen, and an ignition source of sufficient intensity to heat all or a portion of the combustion mixture to the ignition point.

In coal mines, the production of dust is an inherent part of the mining operation. Through the ages very fine dust has been formed in coal seams by natural movement of the coal and by pressure of surrounding strata. This dust is held in slip planes in the seam and is released during mining. Coal dust is also produced during undercutting of the coal seam preliminary to blasting, during drilling of holes for placement of explosive charges, during blasting of the coal with explosives, during mining by continuous mining machines, and during loading and haulage. The total quantity of dust formed daily in the operation of coal mines may amount to as much as 3 to 5 percent of the total coal production. The larger dust particles settle on the floor near their points of origin and can be removed, but much of the fine float dust is transported by the ventilating current and during coal haulage through the mine passageways, where it is deposited overhead on roof and timbers, on side walls or ribs, and on the floor, providing potential fuel for explosions.

In many industrial plants, dust is produced by disintegration of solids, atomization and cooling of liquids, and condensation of vapors as an intermediate or an end-product in the manufacturing process, as in the production of carbon black, metal powders, plastic molding powders, starches, sugars, spices, drugs, and so forth. In other plants, dust is a by-product, mostly of little or no value, formed during machining, cutting, grinding, or other finishing processes.

Causes of Dust Explosions

Although explosions have always constituted a major hazard in coal mining, the dangerous role of coal dust was not recognized for many years. At first, all explosions were thought to be due entirely to the ignition of firedamp, essentially a mixture of methane and air. During the early part of the 19th century, several British and French investigators, notably Michael Faraday, observed that in some explosions coal dust helped to spread the flames. Further proof of this was obtained in experiments in several countries, and eventually it was established that coal dust alone, in the absence of flammable gas in the mine air, can produce explosions when dispersed and ignited.

Much work on mine explosions was done in large-

Fig. 1. Coal-dust explosion demonstration at the experimental coal mine.

scale tests at the experimental coal mine of the U.S. Bureau of Mines at Bruceton, near Pittsburgh (Fig. 1). This mine was established in 1910, after the Courrières explosion in France in 1906, where 1100 men were killed, and the Monongah, Darr, and other explosions in this country in 1907, which cost the lives of more than 900 workers. Today it is known that in nearly every large bituminous coal mine explosion, coal dust is the principal, if not the only fuel.

The first great coal mine explosion in the United States occured in 1884 at the Pocahontas mine in West Virginia, where 112 men were killed. This was followed by many other explosions, some in mines where combustible gas had never been detected. According to statistics of the Bureau of Mines, during the 50 years between 1902 and 1951, 350 major coal mine explosions occurred in the United States, resulting in more than 9300 fatalities. (A major explosion is one that causes five or more deaths.) The frequency of these disasters has decreased markedly in recent years. From 1902 to 1911, more than 100 major explosions occurred, whereas during each of the two recent decades less than 40 such disasters have occurred.

The principal causes of explosions 40 to 50 years ago were open lights, use of black powder and dynamite, and misuse of explosives; in recent years electric arcs from trolley wires and from improperly maintained mining machines and power cables have become the principal igniting source. Other agents that cause explosions are flames from matches and smokers' articles (normally prohibited in coal mines), defective flame safety lamps, mine fires, spontaneous heating, overheated bearings and equipment, and unknown or unaccountable sources.

Potential dust-explosion hazards exist in approximately 30,000 industrial plants in the United States; these plants employ about 1 million workers. The first recorded dust explosion occurred in a flour mill in Milwaukee, Wis., in 1860. Records of the National Fire Protection Association indicate that since then there have been 950 dust explosions, causing 600 fatalities and about 90 million dollars in property damage. The explosions occurred in the production, handling, and distribution of grain dust, wood dust, food and cereal dusts, flour, metal powders, starch and corn products, pulverized coal, cork, sugar, malt, plastics, sulfur, fertilizers, cotton, bark dust, and other products.

In many industrial explosions, the exact nature of the igniting source cannot be determined, because the evidence is destroyed. In several instances, suspicion pointed to static electric discharge sparks as the most probable igniting source, and such sparks have been listed as known causes of a number of grain, starch, cork, metal powder, and other dust explosions. Other sources of industrial dust ignitions are electric sparks and arcs from motors, switches, fuses, and short circuits; welding arcs; frictional or metallic sparks from foreign matter in grinding mills and fans and sparks from grinding wheels; glowing particles; overheated bearings and other hot surfaces, such as steam coils and hot pipes in driers and hot electric bulbs; heating by friction and impact; matches, gaslights, small fires, and other open flames; spontaneous heating of waste, powders, and other materials; boiler backfires; breaks in oil and fuel lines; disturbance of burning dust by use of water hose; small gas explosions; chemical reactions between constituents of dust mixtures; and lightning.

Comparison of Gas and Dust Explosions

In certain respects, dust explosions are similar to gas explosions. The similarity is more pronounced as the particle size of the dust decreases toward colloidal dimensions. As in the case of gas, to produce an explosion, the dust must be mixed intimately with air or some other supporter of combustion. As with gas, an external source of ignition is generally necessary to initiate the explosive reaction in dust clouds. Only in rare instances have explosions been produced by spontaneous rapid oxidation and heating of the dust. Like gas-air mixtures, dust clouds in air have lower and upper explosive limits. The explosions of limit mixtures are weak, and the strongest explosions are produced by dust clouds that have intermediate concentrations. During the initial stages of most dust explosions and of many

gas explosions, there is an induction or ignition-lag period sometimes attributed to initiation of a chain reaction.

The energy developed by complete combustion of dust in a given volume of air is frequently greater than that developed by combustion of gas, and therefore the maximum pressures produced by some dust explosions are higher than those in gas explosions. The reaction rate and the rate of pressure rise in gas explosions are, however, generally higher than in dust explosions. The combustion of dust is a surface reaction—at least in the initial stages—and therefore the diffusion of oxygen to the surface usually is rate-governing. Since even the smallest dust particles are composed of aggregates of many molecules, diffusion toward the reacting surface is necessarily slow, and mixing is much less complete than in gas explosions.

Dust explosions are frequently more disastrous in their effects than gas explosions, because of their longer duration, which results in a greater total impulse, and partly because combustible dust is often widely distributed, either unavoidably, as in coal mines, or through lack of attention, as in many industrial plants. Turbulence enhances mixing of oxygen with the dust particles and promotes thermal diffusion, causing stronger explosions; the effect is somewhat similar in the combustion of gas-air mixtures.

The nature and intensity of the ignition source have important effects on the character of the resulting dust explosions, as in the case of gas explosions. With dusts, the ignition source also frequently produces the dust cloud.

Theories of Ignition and Flame Propagation

The igniting characteristics of flames, hot surfaces, and sparks depend on their temperature and size, the time of contact with the combustible mixture, and the nature of this mixture. To initiate an explosion, an ignition source requires a certain minimum energy that must be imparted to a large enough volume of the dust cloud at an adequate rate. A source that heats only a small portion of the dust cloud generally has a higher temperature rather than a larger source. Most dust clouds can be ignited more readily by flames and hot surfaces than by electric sparks, but there are a few exceptions, for example, clouds of silicon powder and atomized aluminum powder in air.

All ignition sources impart heat to the combustible mixtures. According to the "thermal theory," ignition is effected when a dust-air mixture is heated until its oxidation produces heat faster than heat is lost to the surroundings; this is followed by continued self-heating, which leads to visible ignition at some point. Thereafter the flame is propagated by conduction of heat from the flame front to the neighboring layers of the mixture.

There is evidence that radiation plays a role in the ignition of dust clouds. According to some reports, clouds of aluminum powder and of coal dust have been ignited purely by radiant energy. It has been suggested that, under some conditions, the pressure wave of an explosion can lead to a kind of dynamic shock ignition of a dust cloud; strictly speaking, this is also a thermal ignition, the heat resulting from the compression.

Another view holds that some dust explosions have an electric origin, as opposed to thermal ignition. This is thought to be the case in certain aluminum and sugar-dust explosions. The electric discharges are believed to produce ozone and N_2O_5, which react with the fine sugar dust, or, in the case of aluminum, unstable Al_2O_5, the decomposition of which initiates the explosion.

Electric ignition depends largely on the production of a sufficient concentration of charged particles resulting from electronic collisions; therefore the presence of ions or ionized particles in the explosion space plays an important role. Since activated particles or species are now also thought to participate in thermal ignition, basically the two theories do not differ too widely.

Experience with coal, sugar, and other organic substances containing combustible volatile matter has led many investigators to consider all dust explosions as purely gas or vapor explosions. According to this view, the energy of the ignition source heats the dust particles, causing the evolution of the volatile matter. This gas mixes with air and ignites; the heat thus produced, in turn, ignites the solid particles. This is termed the *predistillation theory* of dust ignition.

One objection to the predistillation theory is that the ignition temperatures of some dusts, including coal dust, are lower than the ignition temperatures of the gases evolved, for example, methane. To this argument, it is sometimes countered that during the initial heating of the dust there is not enough air at the surface of the particles to support combustion; consequently, the temperature rises above the ignition point of the solid, causing the gases to distill and eventually to ignite and, thus, starting the combustion. Another objection to the theory is that the gases and distilled vapors from some highly explosive dusts form almost incombustible mixtures in air. For example, the gases evolved by heating cellulose and starch to a fairly high temperature are composed chiefly of carbon dioxide

and water vapor. Nevertheless, it is true that the volatile content of many dusts plays a most important role in determining their explosibility; this applies particularly to coal dusts, whose explosive properties are closely related to the proportion of their volatile constituents.

Some combustible dusts—for example, aluminum and magnesium—vaporize fairly readily upon heating, and their explosions appear to be initiated by ignitions of their vapors in air. Accordingly, explosions of these and certain organic dusts are homogeneous oxidation reactions, similar to the combustion of premixed gases. Requisites for this type of reaction are that the boiling point of the combustible material be lower than the flame temperature and that the heat of vaporization be lower than the energy required to initiate rapid surface oxidation.

In contrast, the explosions of other dusts constitute primarily heterogeneous reactions coupled with a second-step oxidation in the gas phase. One example is graphite dust, whose combustion produces successively carbon monoxide and carbon dioxide. The rate of these reactions is determined by the oxygen diffusion toward the dust particles. A transition from the heterogeneous to the homogeneous type of reaction might be expected by reducing the particle size of the dust when the effective diffusion becomes greater.

To explain the remarkable effectiveness of certain inhibitors toward explosive reactions, as well as other unusual effects, it has been suggested that some dust explosions might be chain reactions in which unstable active atoms or radicals play an important part in the ignition mechanism.

Effect of Gas on Dust Explosions

The presence of a small percentage of methane in mine air lowers the explosive limit of coal dust, makes the dust cloud more sensitive to ignition, and increases the violence of the dust explosion. A partial explanation offered for these effects is that this gas becomes mixed with the combustible gas distilled from the coal dust during the initial stage of ignition, and thus an explosive concentration is reached sooner than with coal dust alone. Combustible gases undoubtedly play similar roles in other dust explosions. Many explosions of magnesium and aluminum powder have been attributed partly to the presence of hydrogen formed on decomposition of moisture by these metals.

The high reaction rates in some dust explosions are attributed to oxygen adsorbed on the dust particles. All dusts, particularly those with porous structure, adsorb gas from the surrounding atmosphere. The process is selective, favoring adsorption of the most compressible gas, which, in the case of air, is oxygen. The gas diffuses into the particles, where it is partly condensed and held under high pressure, and a thin gas film forms on the surface. Experiments have shown that an excess of oxygen in atmosphere that contains a dust cloud lowers the ignition temperature and increases the rate of combustion; it is a logical assumption that oxygen adsorbed on dust particles exerts similar effects on explosions.

Addition of inert gases, such as carbon dioxide, nitrogen, helium, and argon, to the atmosphere has a flame-suppressing effect on dust explosions, owing partly to the heat capacity and heat conductivity of the gas and partly to the reduction of oxygen partial pressure. For most dust explosions, carbon dioxide is a somewhat more effective suppressor than nitrogen. However, in explosions of magnesium, zirconium, titanium, and some other powders, carbon dioxide is decomposed and is, therefore, ineffective as a diluent. On account of its high heat conductivity, helium was found to be highly effective for suppressing explosions of dust clouds of uranium, thorium, zirconium, and titanium.

Recently it has been suggested that inhibiting action might be provided for some dust explosions, such as for explosive gas-air mixtures, by the use of certain unstable complex organic substances, often of a highly flammable nature. An explanation for this unusual effect lies in the fact that these compounds undergo endothermic decomposition at relatively low temperatures.

Catalytic Action of Dusts

The presence of dusts plays an important indirect role in some chemical reactions that involve gases or other types of dusts. The effect may be rate-promoting, owing to the catalytic action of the solid surface of dust particles, or it may be rate-retarding or inhibiting. Examples of the rate-promoting action of dust can be found in the reduction of the lower explosive limit of methane in air in the presence of small concentrations of coal dust; the enhancement of explosions of fuel vapor-air mixtures by iron oxide particles; the increase in the combustion reaction regions of various gases by some dusts; the increase in the rate of thermal decomposition of hydrogen peroxide by dust; the action of powdered catalysts in coal hydrogenation; and the effect on spark incendivity of platinum, copper, and iron coatings on the tips of electric-spark electrodes. Dusts act as negative catalysts by serving as chain breakers, by forming intermediate compounds of great stability, or by

producing intermediate compounds that decompose to generate the catalyst and the original reactant.

A most important application of dust for limiting chemical reactions is the use of rock dust to stop explosions in coal mines. The rock dust, generally ground limestone, is applied on the floor, walls, and roof of the mine workings, where it covers or mixes with the coal dust. When an explosion starts, the pressure wave that precedes the flame front disperses the rock dust and coal dust into the air. If enough rock dust is present, the flame is soon quenched, owing partly to the diluting effect and heat capacity of the rock dust and partly to its absorption of radiant energy. Dispersibility of rock dust is one of its important requirements. Some work indicates that water of hydration in the dust and production of carbon dioxide during heating may be helpful.

Laboratory experiments have shown that many chemical compounds may be better suppressors of coal-dust explosions than limestone. Among these are sodium and potassium halides, sodium bicarbonate, calcium sulfate, sodium sulfate, various oxidizers, and other compounds. The order of effectiveness varies for explosions of different combustible dusts, and no entirely satisfactory explanation has been given for the mechanism of the inhibiting action. In the case of oxidizers, it is believed that their usefulness is due to their heat conductivity. The action of sodium and potassium halides has been studied quite extensively, and it was found that fluorides are most effective, followed by iodides, bromides, and chlorides. This order cannot be fully explained on the basis of specific heats, molecular heats, heat conductivities, or otherwise.

Factors That Affect Explosibility of Dusts

The ignition sensitivity of dusts and the violence of explosions depend on several interrelated properties of the dust and on surrounding conditions. A brief discussion of some of these factors follows.

Chemical and physical properties of dust. Among the chemical and physical properties of coal dust are its composition, affinity for oxygen, heat of combustion, volatile matter, moisture and ash content, specific heat, particle size. The effect of volatile matter is especially evident in coal dusts of various ranks, as has been noted; the low volatile content of anthracite is a chief cause for its low explosibility.

The size, shape, and surface structure of dust particles influence their explosive characteristics. Experiments have shown that, when some finely divided dust is present, particles of coal as large as 800 microns (800 μ) in diameter contribute to the explosion. In general, the explosibility of dusts increases with a decrease in particle size, because finely divided dust has a higher specific surface. This means better mixing of the particles with oxygen, more rapid vaporization, and higher rate of oxidation; the volume of oxygen adsorbed per unit weight of dust is greater for fine particles; the electric capacitance per unit weight of fine dust is greater, and therefore larger charges can be developed; and fine dust is more readily dispersible and remains in suspension longer. In a few instances, it has been observed that the very finest coal dusts are less reactive than somewhat coarser fractions. This is thought to be due to the agglomeration and reduced dispersibility of the fine particles, the formation of a less sensitive oxide layer on the surface during elutriation, and possibly the fact that during disintegration the less reactive portions of the coal formed the finest particles.

Dust concentration and uniformity of dust clouds. It has been mentioned that, to have an explosion, the concentration of dust in a cloud must lie between certain limits. The lower explosive limit corresponds to a concentration at which there is barely enough dust in the air to propagate flame. The upper limit may be defined as the concentration at which the heat produced by complete oxidation of a portion of the dust in the available oxygen is just enough to heat the rest of the dust in the mixture to the ignition temperature. Actually, dust clouds do not have definite upper limits, because, as the concentration increases, partial burning of all the dust takes place. Theoretically, neglecting dissociation, the strongest explosions should be produced at a concentration corresponding to stoichiometric mixture; this can be computed if the chemical composition of the dust is known and if complete combustion is assumed. Actually, somewhat richer dust mixtures are the most explosive. The problem is more difficult if, in addition to oxides, nitrides and other compounds are formed during combustion.

Composition of atmosphere. The initial temperature, pressure, oxygen content, flammable vapor and gas content, humidity, specific heat, and heat conductivity of the atmosphere all influence dust explosions. In practice, oxygen is the most important factor. Most dusts do not ignite and propagate flame if the atmosphere contains insufficient oxygen. This fact is utilized in several industries to provide protection against explosions. On the other hand, the explosion hazard of dusts in oxygen-rich atmospheres is greater than in air.

Ignition source. The importance of the temperature, energy, and surface area of the ignition source

and time of contact with the dust have been mentioned. Most industrial dusts ignite more readily by flames and hot surfaces than by electric sparks, but there are some exceptions.

Explosion space. The size, shape, strength, and other features of the explosion space have an important bearing on the elutriation of dust and formation of the dust cloud, initiation and development of an explosion, flame speed, and pressure relief; these in turn determine the degree of destruction produced by an explosion.

Effect of moisture. Free and combined moisture in dust usually acts as an incombustible. Energy is required to heat and vaporize the moisture, reducing the energy available for ignition of the dust cloud, and the water vapor acts as an inert gas, diluting the atmosphere. Frequently, a more important effect of moisture is its ability to wet and agglomerate dust particles, thus reducing their dispersibility.

In coal mines, fine water sprays are used to induce settling of float dust and to consolidate loose dust on the mine floor. Another effect of moisture is its ability to promote leakage of static electricity along the surface of nonconducting materials. Despite these actual and apparent benefits, complete reliance cannot be placed on moisture to prevent dust ignitions and explosions, either in coal mines or in industry. Reaction of moisture with magnesium, aluminum, and a few other metals results in the evolution of hydrogen gas, particularly at elevated temperatures. This may reduce the surface oxide coating and make the dust highly sensitive to ignition.

Hazards of dormant dust—secondary explosions. Although it is true that to produce explosions the dust must be dispersed, the potential hazard of undispersed combustible dust on exposed surfaces in the path of an explosion or near the source of ignition must not be neglected. An excellent illustration of this is found in coal mines. When a localized gas explosion occurs or a small cloud of dust is ignited, the resulting pressure wave throws the dormant coal dust from the floor and walls of the passageways in the path of the flame into suspension, and a widespread explosion may develop. Similarly, in industrial plants the first ignition frequently involves only a small dust cloud and causes little damage, but if enough dust is present on nearby surfaces, this may be dispersed, causing a second and, possibly, a third much stronger explosion.

Spontaneous combustion. Spontaneous heating and combustion is of great importance in coal mines and in industrial plants. Since the process is essentially a surface reaction, powdered products are often more capable of heating than solid material in bulk. Many substances, both organic and inorganic, are subject to spontaneous heating. They include coal, agricultural products, certain metal powders, charcoal, and other porous materials, as well as paints, oils, and chemical compounds.

When stored under certain conditions in large quantities, some substances begin to heat at room temperature, but in most instances heating does not begin unless the ambient temperature is elevated. Initially the heating may be caused by external sources, such as flames, hot surfaces, and friction. The presence of small quantities of moisture often accelerates spontaneous heating. In coal mines and in coal storage piles, the age and rank of coal, its fineness, the degree of ventilation, the volume of coal stored, the initial temperature, and the manner of storage are important factors in heating. Anthracites are less subject to heating than bituminous coals and these are less affected than subbituminous coals and lignites. Freshly mined coals heat more rapidly than coals that have been exposed to air for some time. The presence of pyrites is considered to play some role in the oxidation of coal.

With hay, starch, sugar, cellulose, and other materials, initial heating is thought to result from fermentation or some other microbiological action. As the temperature rises, this is supplanted by chemical oxidation of the material. In other cases, the entire process may be due to the action of atmospheric oxygen on the combustible substance.

Preventive measures against spontaneous heating vary according to the nature of the material involved. Storage in cool areas removed from external sources of heat and free of moisture is usually recommended. For coal storage, the following measures are sometimes advised: storing large sizes of coal; preventing segregation of sizes in a coal pile; storing in small piles and keeping the storage height as low as possible; compressing piles in layers to prevent access of air; and, in some instances, storage under water. In coal mines, avoidance of undue pressure on seams liable to spontaneous combustion is important; this prevents the formation of cracks and disintegration of the coal.

Pyrophoric dusts. Some very finely divided metal powders (iron, manganese, copper, uranium, nickel, cobalt, chromium, lead, tungsten, molybdenum, zirconium, and others), metal oxides, hydrides, carbides, nitrides, and metal alloys oxidize so rapidly on exposure to air that they heat and ignite. In some instances this action occurs at room tempera-

ture; in others, only at elevated temperatures. There is no agreement regarding the exact mechanism of pyrophoric ignition. The process probably varies somewhat with the type of dust, its fineness, surface character, and other properties.

According to one view, pyrophoric behavior is due simply to rapid oxidation of the very large total surface of finely divided particles, with consequent liberation of heat. Other theories suggest that finely divided oxides in the powder play a role, that pyrophoricity is related to a metastable internal equilibrium in the powder, and so forth. The presence of hydrogen gas in the powder is not believed to affect heating. Some proposed remedies for avoiding ignition are to store the powder in small batches, to keep it away from direct sunlight and other heat sources, to provide storage under protective liquids or in inert gases, and, in some cases, to permit slow but limited access of air to the powder before complete exposure to air.

Effect of static electricity. Static electric charges develop whenever two dissimilar surfaces are pressed together and separated. The charge may become appreciable when one or both of the surfaces are nonconductors and when the atmospheric humidity is low. In industry, electrostatic charges can develop on dust and on dust-containing equipment during grinding, mixing, sieving, and transportation of dust through ducts and on conveyors, and also from transmission of power by belts, movement of vehicles and people, and during other operations involving motion. The quantity of charge depends partly on the capacitance of the system, which in turn depends largely on the total surface area and spacing of the charged parts and the dielectric constant of the intervening medium. The capacitance of a dust cloud increases with its volume and density. In a dust cloud of given weight concentration, the capacitance increases with a decrease in particle size and a corresponding increase in the number of particles. The ignitibility, likewise, increases with reduction of the particle size.

Theoretically, it may be possible for a high-capacitance dust cloud composed of extremely fine particles to self-ignite by an electrostatic-spark discharge within the cloud. It is not known whether this has ever occurred in practice, but it may explain a number of unusual ignitions observed during experiments with zirconium dust clouds in air. However, ignitions of dust clouds in industry usually are effected only by the more intense electric discharges between different pieces of equipment or between the equipment and the ground. Ignition sparks are characterized by a certain minimum energy and minimum spark gap, by the electric potential, and by the resistance in series with the spark gap.

The best measure against ignitions by static sparks is prevention of accumulation of electric charges on equipment and, if necessary, on operating personnel. This can usually be accomplished by careful bonding of all conductive parts of the equipment and by connecting them to a common ground. Strong sparks usually cannot be produced by direct discharge of nonconductors; however, charged nonconductors present a hazard, because they may induce charges on nearby conducting surfaces. To reduce charge accumulation on leather belts and similar surfaces, conducting dressings can be applied or the charge removed by placing near the nonconductors grounded metallic combs or other improvised or commercial static eliminators with sharp point collectors. Other methods that can be employed are ionization of the air, which promotes neutralization of static charges; maintenance of high atmospheric humidity, which assists charge leakage by formation of a thin film of moisture on surfaces of equipment; and design of the system to reduce its electric capacitance.

Experimental Investigations

Experiments on coal mine explosions were started more than 40 years ago. In Europe, large-scale tests are made chiefly in surface galleries, although in recent years studies have also been made in experimental mines in Germany and Poland. In the United States, investigations are conducted principally at the experimental coal mine of the Bureau of Mines. The Bureau has been cooperating for many years in mine safety research with other countries, especially Great Britain.

Systematic research on industrial dust explosions in the Netherlands, Germany, England, and the United States is more recent. In this country, much of the work has been centered in laboratories of the Bureau of Mines of the U.S. Department of the Interior, but many special investigations were made at laboratories of the U.S. Department of Agriculture and a few national insurance and safety associations. Apparatus and experimental techniques have undergone many changes, and there is little uniformity in the procedures employed by different investigators. This fact, together with difficulties in producing uniform dust clouds, the importance of timing ignition with dust-cloud formation, employment of different igniting sources, and variations in dust samples, accounts for differences in published data. Following is a brief outline of research currently in progress at the Bureau of Mines, where dusts of many varieties have been studied.

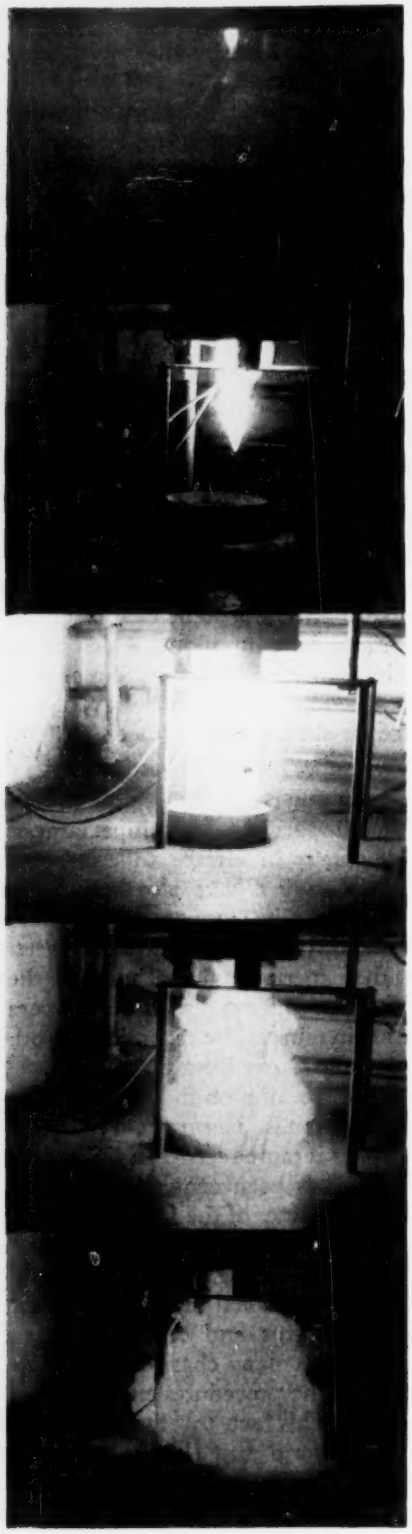

Fig. 2. Ignition of magnesium powder in laboratory furnace (120 frames per second).

The mechanism of ignition of dust particles and flame propagation in dust clouds are being investigated chiefly on stationary dust flames in air and other gases. This affords opportunity for photographic and other measurements and studies of burning velocity, effect of diffusion, effect of radiation, turbulence, vaporization before burning, and other combustion characteristics and phenomena.

In evaluating the explosive characteristics of dusts, tests are usually made with samples finer than 200-mesh (74 μ), but special experiments are performed on dusts of different particle sizes.

Dusts that contain less than 5 percent free moisture are tested without drying; other samples are dried at 75° C for 24 hr before tests. Drying at higher temperature is avoided, because some materials soften or emit vapors during heating at 105°C. Dry dusts are generally more dispersible, have a lower ignition temperature, require less energy for ignition, and produce stronger explosions. Limited tests made at different atmospheric humidities indicate no perceptible effects on dust explosibility. High humidity is employed sometimes to reduce the accumulation of static charges, as has been mentioned.

Dust-cloud ignition temperatures in air are determined by rapidly projecting small amounts of dust, generally 1 g or less, downward through an electrically heated cylindrical alundum-core furnace. Figure 2 shows ignition of magnesium powder in the apparatus. The ignition temperature (for some dusts, visible glow; for others, flame) of dust layers is determined by exposing a small sample for several minutes in a heated furnace through which air streams slowly. Ignition temperatures for the dusts studied range from about 200°C to more than 1000°C. Table 1 lists ignition temperatures and other experimental data for four types of important industrial dusts.

There is a great variation in published data for the lower explosive limits of dust clouds, because, in this determination, fineness (Fig. 3), dispersibility, uniformity of dust cloud, igniting source, timing of ignition, and interpretation of what constitutes limiting flame propagation are very important. Published figures for the lower limit of aluminum powder range from 7 to more than 400 mg/liter. The range in values for the dusts studied by the Bureau of Mines is from 10 to 15 up to several hundred milligrams per liter. Figure 4 shows a simplified portable model of the apparatus, designed by the writer, that is used for lower limit and other laboratory research.

Many procedures have been proposed for rating the relative explosion hazards of dusts. These in-

Table 1. Explosibility data for four dusts*

Dust	Ignition temperature (°C)		Minimum energy required for ignition of dust cloud (mj)	Minimum explosive concentration (mg/liter)	Maximum pressures and rates of pressure rise developed by explosions of dust clouds at 500-mg/liter concentration			Limiting oxygen percentage to prevent ignition of dust clouds by	
	Dust cloud	Dust layer			Pressure (lb/in.²)	Rates of pressure rise (lb/in.² sec)		Electric spark	Hot surface at 850°C
						Average	Maximum		
Pittsburgh coal	600	210	40	55	83	800	2,500	16	9
Cornstarch	380	230	40	45	105	2000	7,000	11	5
Cellulose acetate	420	390	20	35	110	2500	5,500	9	3
Magnesium	520	490	20	20	95	3000	> 10,000	†	†

* The data represent limiting rather than average values obtained in tests on several samples of each of the reported dust types. Pressure and rates of pressure rise developed at 500 mg/liter concentration are not necessarily the highest that can be produced.

† Oxygen reduction tests were made in air-carbon dioxide mixtures; dust clouds of magnesium were ignited in pure carbon dioxide.

clude classifications according to ignition temperature, volatile content, lower explosive limit, minimum energy required for ignition, flame velocity, pressures and rate of pressure rise developed by dust explosions, ratio of heat of combustion to the heat necessary to bring the dust cloud to the ignition temperature, and the percentage of inert dust needed in a mixture with the combustible dust to prevent ignition and flame propagation under certain standard conditions (termed *relative flammability*).

Actually, no single characteristic is adequate to classify the sensitivity of dusts to ignition and the destruction that may result from explosions. However, as a result of coal mine explosion studies by the Bureau of Mines, dusts are occasionally grouped according to their relative flammabilities. The proportion of inert dust needed to prevent ignition is determined in the laboratory furnace at a temperature of about 700°C, and in another test by passing a high-voltage continuous induction spark through the dust cloud. The furnace test was designed so that mine-size coal dust (100 percent through 20-mesh, 20 percent through 200-mesh) from the Pittsburgh seam has a relative flammability of 65 percent, which corresponds approximately to the findings in large-scale explosion tests in the experimental coal mine. The relative flammabilities of other dusts on this scale range from 0 to more than 95 percent.

The minimum energy required for ignition of dust layers and of dust clouds is determined by using electric discharge sparks from condensers charged to different voltages. The igniting energy of dust clouds varies with the fineness (Fig. 3), the moisture content, and somewhat with the concentration of the cloud. Undispersed layers of zirconium powder have been ignited by sparks of less than 1 microjoule (1 μj) energy; other dusts require considerably stronger sparks. The igniting energy of dust clouds in air ranges from about 10 millijoules (10 mj) to several joules.

The pressures and rates of pressure rise developed by explosions of dust clouds in a closed test bomb are determined at various concentrations (Fig. 5). The igniting source generally employed is a high-voltage induction spark. Maximum pressures developed by highly explosive dusts range to more than 150 lb/in.², the average rates of pressure rise to about 5000 lb/in.² sec, and the maximum rates to more than 10,000 lb/in.² sec.

The limiting oxygen content of the atmosphere for preventing ignitions of dust clouds is determined in the presence of a continuous high-voltage induction spark and, in some cases, also by dispersing the dust through the furnace set at 850°C. Except for dusts that decompose carbon dioxide and a few that react with nitrogen at elevated temperatures, the tests are generally made with mixtures of carbon dioxide and air or nitrogen and air. The ignition of most dusts by electric sparks can be prevented when the oxygen content is less than 10 to 12 percent; in the presence of very hot surfaces the oxygen limit may have to be reduced to 5 percent or less.

Explosion venting experiments are performed for the most part in cubical boxes, or galleries, 1, 64, and 216 ft³ in volume, provided with adjustable

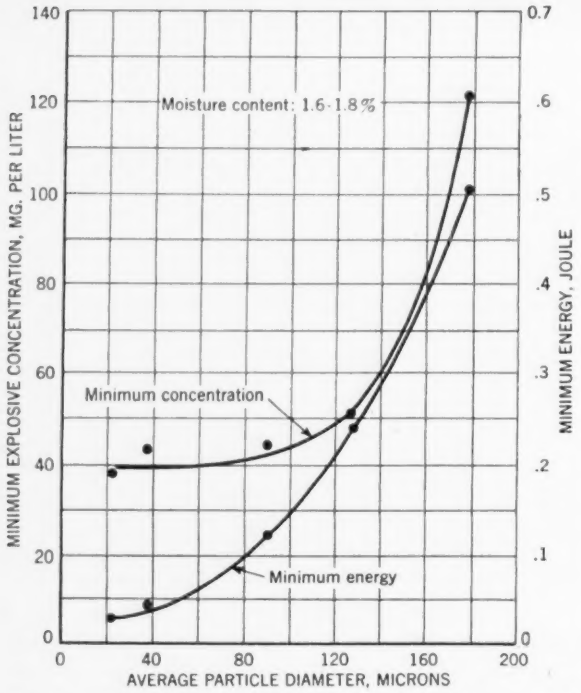

Fig 3. Effect of particle size on lower explosive limit and minimum energy required for ignition of cornstarch dust clouds in air.

openings or vents to which ducts can be connected. The function of the vents is to release rapidly the gaseous combustion products during the incipient stages of an explosion, thereby reducing the rate of the reaction and preventing full development of pressure within a structure. The required size of vents depends on the nature of the explosion to be released, on the strength of the structure to be protected, and on other factors. Free openings without any restrictions make the most effective vents, but they can rarely be used in practice. Vent openings may be closed by diaphragms, hinged panels, scored glass panes, or other types of closures. In addition to size, the effectiveness of vents depends on their speed of operation, location, number, and shape; the presence of ducts and weatherhoods also influences the effectiveness of vents. Whenever possible vents should be located near the origin of an explosion; they should provide a direct exit for the gases to the outside atmosphere. When ducts are needed to guide the flow into the open, they should be as short and straight as possible. Figure 6 shows the relationship of vent size (expressed as a ratio of vent area to volume of enclosure) to the explosion pressures of four dusts; the data are based on experiments in a 1 ft^3 chamber, using unrestricted vents. Recommended venting areas range from about 1 $ft^2/80$ ft^3 to 1 $ft^2/10$ ft^3.

Investigations on coal mine explosions cover a wide range of problems, and many reports have been published. Highlights of some of the findings can be summarized as follows. The explosibility of coal dust increases with the volatile content, but even coal dusts with as little as 10 to 12 percent volatile content can produce and have produced explosions. Neither so-called "dustless zones" nor wet zones in mine entries can be depended on to stop explosions. Moisture is helpful to the extent that it reduces dispersibility, but even moist coal dust, once dispersed into air by a small gas explosion or otherwise, can propagate explosions. High atmospheric humidity has little or no effect on explosion propagation, nor does the direction of the ventilating current. The minimum concentration of coal dust that will propagate large-scale explosions is approximately 50 mg/liter (0.05 oz/ft^3) of air. Strong explosions can be produced in relatively short, wide, connected rooms as well as in long narrow entries. The violence of coal-dust explosions generally increases with distance from the point of ignition, unless propagation is checked. Flammable gas in the atmosphere promotes ignition and propagation. Explosion flames are usually preceded by an air-pressure wave, and immediately following passage of the flame there is a low-pressure wave traveling back toward the origin of the explosion. In experimental explosions in a 1300-ft long entry, pressures of nearly 150 $lb/in.^2$ (20,000 lb/ft^2) and flame velocities in excess of 6000 ft/sec have been recorded. Proper application of rock dust in mine entries, in sufficient quantity to render the incombustible content of mine dust at least 65 percent, is effective in preventing propagation of coal dust explosions. When gas is present in the mine atmosphere, additional use of rock dust is required.

Prevention of Dust Explosions

Much attention has been given to the prevention of dust explosions in industry, and special technical committees of the National Fire Protection Association have prepared detailed safety codes for several industries. Preventive measures are directed principally at reducing the formation and dissemination of explosive dust in plants and at eliminating all ignition sources from hazardous areas. Recommendations in the codes cover proper building construction and layout, segregation of dangerous processes, safe design and operation of equipment, provision for adequate explosion vents, use of inert gas with low oxygen content in some instances, and many other problems. Great stress is placed on good housekeeping, frequent cleaning, good ventilation, use of dust collectors, reducing production of

very fine dust, and necessary measures to prevent dissemination of dust.

To prevent ignition of dust, smoking and use of open lights must be prohibited; electric equipment and wiring should conform to the requirements of the National Electrical Code for dusty areas; all equipment should be properly grounded and other steps taken to remove accumulation of static charges, as mentioned in a preceding paragraph; torches and welding equipment should be used only during shutdowns and after removal of all dust; bearings of machines and other moving parts should be inspected for signs of heating; entry of foreign matter into grinding mills and fans should be prevented; in some plants nonsparking, nonferrous tools and nonferrous fan blades should be used to eliminate frictional sparks. It is advisable to maintain fairly even temperature and ventilation in dust-producing plants to avoid raising dust by air currents. Special attention should be directed to preventing ignition at the beginning and toward the end of a working shift when the dust concentration in some equipment passes through the explosive range. When a plant is to be closed for a few days, it may be advisable to remove the dust from all equipment.

In coal mines, many explosions are started by gas ignition; it is therefore important to eliminate gas from the mine atmosphere. To achieve this, careful attention must be given to roof control, haulage control, adequate ventilation to dilute the gas, and use of flame safety lamps and other gas-detecting devices. In some highly gassy mines in several countries, the gas is removed in advance of mining by drilling long holes into the coal seam and the surrounding strata and pumping the gas out. To avoid ignition of gas and coal dust, all possible sources of ignition must be eliminated from

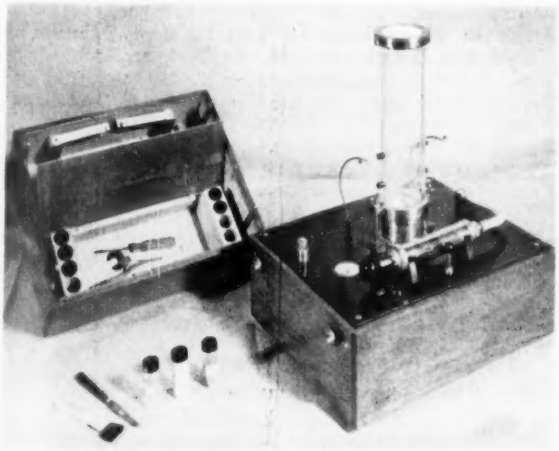

Fig. 4. Portable dust-explosion apparatus.

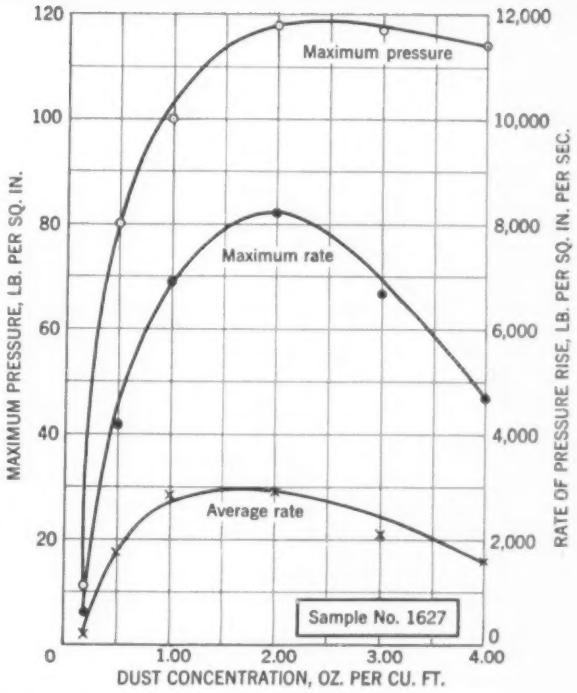

Fig. 5. Effect of concentration on maximum pressure and rates of pressure rise developed by explosions of zirconium hydride in laboratory test bomb.

mine workings. This means prohibition of smoking, avoidance of open lights, care in the use of welding and cutting equipment for track repair, avoidance of spontaneous fires in coal and in opening abandoned workings, preventing heating of conveyor belts, use of permissible electric machines, lights, and equipment, proper installation and maintenance of power lines, and use of permissible explosives in a well-defined and safe manner.

The production of dust can be reduced at its source by use of water sprays, possibly with wetting agents, on cutting machines and drills and at loading points; by use of tight cars and dust collectors at transfer and other points; by use of sharp cutting bits and drills and control of their speed; and by other measures. Experiments are in progress to study the effectiveness of infusing water under pressure into the coal seam in advance of mining; in some areas, this has been most helpful in reducing dust formation. Use of large exhaust dust collectors on mining machines and elsewhere requires investigation. From time to time, it has been suggested that adhesive sprays be applied to the walls and roof of mine entries in order to bind the loose coal dust; so far this has not been found practical. Loose dust on the floor of coal mines can be reduced partly by removal from the mine and partly by consolidation of the roadways.

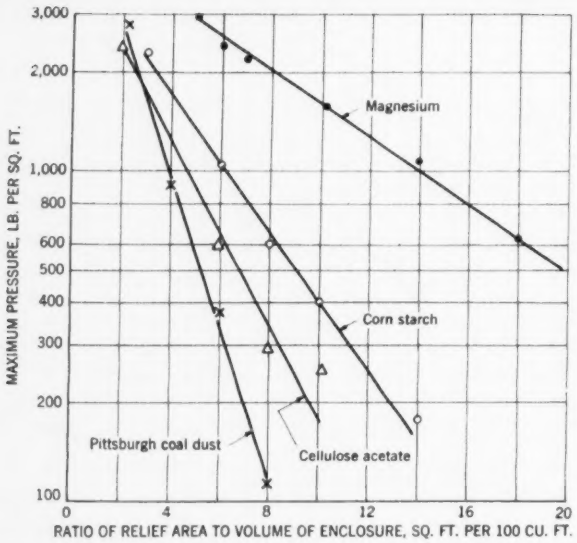

Fig. 6. Effect of unrestricted vents on pressures developed by dust explosions in a 1-ft^3 test gallery.

At present, the most effective practical measure for limiting propagation of coal mine explosions is to rock-dust all mine workings. The material generally used for this purpose is ground limestone dust, distributed by machines or frequently by hand. When an explosion starts, the limestone is thrown into suspension, together with the coal dust. Its effectiveness depends on its diluting effect, heat capacity, and the absorption of radiant energy. To be useful, rock dust must have a certain fineness and a specific gravity not too different from that of coal dust; it must be readily dispersible; it should not absorb moisture readily or cake; it should contain very little, if any, combustible material and practically no silica; it should have no toxic effect; it should be light in color, inexpensive and readily available; and it should not deteriorate in storage or on exposure in the mine. The possible use of water under pressure or in troughs to form water curtains in the path of an explosion is receiving attention.

Fires in combustible dusts are fairly frequent in industry, particularly in some organic materials and others that have low ignition temperatures. Ignitions have been caused by hot electric bulbs, by overheated bearings and other hot surfaces, by glowing particles, by electric arcs, by flame, and by spontaneous heating.

In many cases, it is best to allow the fire to burn itself out, making certain that it does not spread to the surroundings. In fighting dust fires, it is important not to disperse the dust. Fine water sprays and fog nozzles can generally be used without too much danger, although water will accelerate the burning of certain metal powders. Small metal-powder and other dust fires can be controlled by careful covering with sand, talc, or other dry inert materials that prevent the access of air. Firemen should be warned to use large hose streams with caution in fighting fires where combustible dusts are present.

Knowledge of dust-explosion phenomena has been considerably advanced in recent years, and many effective safeguards against explosions were developed. However, there still exist wide gaps in our understanding of the basic mechanism of ignition of dust particles, flame propagation through dust clouds, the role and effectiveness of inhibitors on dust flames, and other related problems. Considering the great economic and human losses from accidental dust explosions and the increasing use of combustible powders by industry, fundamental and applied research in this field should be intensified.

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Thought is the by-product neither of perfect idleness nor of great activity but is an accidental sprout that appears unexpectedly on the vine of one's daily routine and that can be cultivated if one catches it soon enough and tends it with some kindliness and patience.—"The talk of the town," *The New Yorker* (22 May 1954), p. 23.

Importance of Rhythm in Songs for the Treatment of the Sick by American Indians

FRANCES DENSMORE

Dr. Densmore is a collaborator of the Bureau of American Ethnology of the Smithsonian Institution and an associate in ethnology of the Southwest Museum, Los Angeles, Calif. Her research in Indian music for the Bureau of Ethnology began in 1907 and has included Indians in all the principal areas from Florida to British Columbia. Her recordings comprise the Smithsonian-Densmore Collection of Indian song recordings that is at the Library of Congress. These songs are now being issued on long-playing disks, together with descriptive pamphlets, by the Library of Congress. Prior to her study of Indian music, Dr. Densmore taught piano and was church organist in St. Paul and Red Wing, Minn. Her musical education included work at the Oberlin Conservatory of Music and private instruction from Carl Baermann in Boston, John K. Paine of Harvard University, and Leopold Godowsky in Chicago.

IT is always gratifying to have an early observation confirmed by further study of the subject. Such an observation concerning Indian songs for the sick was contained in an earlier article of mine (*1*) which stated:

> The Indian medicine man treats physical as well as mental and nervous disorders with the aid of music, but there is no appeal to the emotions in his method. Instead, it appears to be based on the actual power of rhythm.

This statement was based on a study of the subject for the Bureau of American Ethnology of the Smithsonian Institution that began among the Chippewa in 1907 and included the Sioux, Northern Ute, and Papago. The research was later extended to the Menominee, Seminole, Yuma, and Winnebago, and to the Makah and Clayoquot at Neah Bay, Wash., as well as to Indians in British Columbia. Such songs also were recorded by Tule Indians from Panama who were temporarily in Washington, D.C. A similar research among the Cheyenne was conducted for the Southwest Museum of Los Angeles and included songs for the sick recorded by an Indian from Santo Domingo Pueblo.

The healing songs of these tribes were recorded by 43 men and women, 23 of whom were then using the songs in treating the sick. Twenty-three singers recorded their individual songs and 20 recorded songs learned from their ancestors who were medicine men or from the medicine men on their reservations. Fourteen localities are represented in this research and 197 of the recorded songs were transcribed.

A characteristic of these songs is an irregular rhythm produced by frequent changes of accent. "A tabulation of these 197 songs . . . shows that such a change occurs in 173, or about 88 percent of the number. In a similar analysis of 1510 songs of all classes, from many tribes, only 83 percent contain a change of accent" (*2*). The irregular accents are shown by changes of measure lengths in the transcriptions, and they constitute the simplest form of peculiar rhythm in Indian songs for the sick. Other peculiarities wil be considered. Rhythm is an important factor in all Indian music, and I have given special attention to it (*3–5*).

The action preliminary to the treatment of the sick and the conditions under which the treatment is given are somewhat similar in the various tribes. The medicine man consults the spirits from whom, he believes, he receives his power. He asks whether the treatment will be successful and also asks their cooperation. Without such assurance, it is believed that the treatment will fail. The spirits are generally those of animals living in that region. Thus a song of a Chippewa medicine man contains the words "The big bear, to his lodge I go often" (*6*). A Pa-

pago healing song contains the words: "I know everything from the bottom of my heart. From Coyote I learn all this. I get it and keep it within me and hold it there" (*7*).

An instance of this custom came under my observation in 1930 at Grand Portage, Minn., a small Chippewa village on the northern shore of Lake Superior. I had visited the village in 1905 and returned to collect specimens for the Minnesota Historical Society. One evening I saw a small conical tepee where none had stood previously. The air was calm and yet this little tepee swayed to and fro as though a mighty wind were blowing. A friendly Indian told me that a medicine man was in the tepee and had summoned the spirits to tell him whether to undertake the treatment of a certain sick man. The next day I was told that the response of the spirits had been favorable and that the treatment had begun. Later I learned that the sick man recovered.

In some tribes, the patient is required to make a payment to the medicine man before the treatment is begun. This payment is charged according to his means and may be only a handkerchief, a little food, or 4 yards of calico. Lacking this, it is said the treatment will fail.

A condition of the treatment in all tribes is that there shall be no weeping or excitement in the room, and that if persons must move about the room, they do so in a matter-of-fact manner. The atmosphere of the room must be cheerful.

With the patient quiet and relaxed, the medicine man assures him of his power, often telling him its source and relating successful cures. He may express this by means of a song, such as the following, which was recorded by a Chippewa medicine man (*8*).

> You will recover, you will walk again.
> It is I who say it. My power is great,
> Through our white shell
> I will enable you to walk again.

The white shell mentioned in this song is the emblem of the Midewiwin, a religious organization.

In some songs, the rhythm and also the melody seem to express the purpose. Charles Wilson, a Yuma medicine man, sings only four songs, and his treatment lasts about half an hour. It is said that he never lost a case and yet he does not absolutely promise the sick man that he will recover. He asks the patient how he feels after the fourth song, and "he has always said that he felt better." A gentle, swaying phrase occurs in all these songs and would have a soothing effect. The songs are long—the transcription of one contains 80 measures—and the tempo is slow (♩. = 88) except in the first measure, which is still slower. The measure lengths are 2-4, 3-4, 5-8, and 6-8, with many subtle changes in rhythm. Figure 1 shows the recurrent phrase (*9*).

An interesting medicine man of the Northern Ute was Pa′gits, who recorded 10 songs. He received his power from "a little green man who lives in the mountains" and said, "I always tell the sick man that he will recover *because I know it is true.*" Firmness and confidence are expressed in both the rhythm and melody of his song, which is shown in Fig. 2 (*10*).

Brave Buffalo, a Sioux medicine man, recorded a song with the words, "Sunrise may you behold." The treatment of the sick was usually given at night, and it was believed that if the sick man lived until sunrise he would recover. The rhythm of this song is cheering but not stimulating, and the melody contains slight changes in rhythm that would tend to hold the attention of the listener (*11*). This can be seen in Fig. 3.

A particularly interesting informant was John Butcher who lived at the junction of the Thompson and Fraser rivers in British Columbia. His songs were recorded in a hop-picking camp near Chilliwack, B.C. where many Indians find seasonal employment. He recorded four songs that he uses in cases of confinement. The phrases in these songs are short. The first song consists of phrases three or four measures in length, whereas the others contain phrases only two measures in length, each followed by a short rest. The principal count division consists of two 16th notes followed by an 8th note. The first 16th note is accented, which gives an effect of urgency. During this song, Butcher pauses and imitates the voice of a deer; it is said that "the deer is a particularly good helper in such cases" (*12*).

Another medicine man found in the hop camp was Tasalt who recorded four songs, with one introductory song, that he uses in treating smallpox, fever, palsy, hemorrhage from the lungs, and pneumonia. The song for treatment of palsy has a particularly steady rhythm, well adapted to its purpose. The song for the treatment of hemorrhage from the lungs is a gentle melody in a slow tempo (♩ = 58) without any rhythms that would excite the patient (*13*).

A third singer in the camp was Knightum, from Vancouver Island, whose grandfather is Y'ak, a medicine man. In cases of serious illness, his grandfather asks others to join in his songs, thus adding their power to his own, a custom observed in other tribes. In this manner, Knightum learned many of his grandfather's songs. The words of some of these songs mention the source of power; one briefly

Fig. 1. Phrase from Yuman song for the sick. Voice, ♩ = 80. Drum not recorded.

Fig. 2. Northern Ute song for the sick. Voice, ♩ = 58. Drum not recorded.

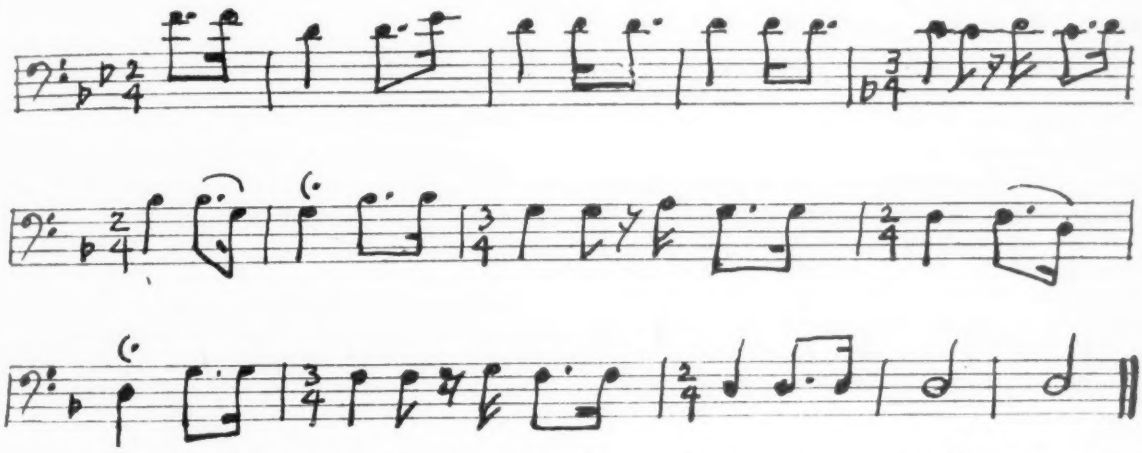

Fig. 3. Sioux song for the sick. Voice, ♩ = 84; drum, ♩ = 72. Drum in unaccented 8th notes.

translated is "The whale is going to help me cure this sick man" (*14*). This does not have the active rhythm noted in many of these songs. The phrases are very short, all are in a descending progression, and the principal count division is a triplet of 8th notes.

Interesting rhythms were found in songs for the sick recorded by Susie Tiger, a Seminole medicine woman, and by Bob-tailed Wolf, a Cheyenne medicine man, who has a special song with a very simple rhythm for treating babies. It is said that he understands what the sick babies say and that they tell him where they feel bad (*15*). This man received his power in a dream of the thunderbird and the sun.

Owl Woman, a Papago medicine woman, asked that her songs be recorded by Sivariano Garcia, a medicine man who generally sings the songs while she treats the patient. He recorded 23 such songs which she selected, one after another (*16*). Among the healing songs recorded by the Menominee is one attributed to the woodpecker (*17*). It has no rhythmic unit. The healing songs of the Tule Indians from Panama are without rhythmic units, their rhythm suggesting spoken sentences. These peculiarities are noted also in songs for the sick from Santo Domingo Pueblo.

The songs for treating the sick are generally accompanied by the shaking of a rattle, but a small drum is used in some tribes. The steady rhythm of the accompanying instrument seems to be part of the rhythm of the treatment.

Music therapy, in various forms, is being recognized by the medical profession. In this connection, it is interesting to note that "according to Pichot, mentally defective persons are more easily handled when soothing rhythmic music is performed." (*18*).

The statement that ended my paper of 1923 seems fitting here: "Perhaps these old men, with their ascetic lives and tremendous powers of con-

centration, could teach the white race a lesson in the curative power of rhythm" (*19*).

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Things are so strictly related, that according to the skill of the eye, from any one object the parts and properties of any other may be predicted. If we had eyes to see it, a bit of stone from the city wall would certify us of the necessity that man must exist, as readily as the city. That identity makes us all one, and reduces to nothing great intervals on our customary scale. We talk of deviations from natural life, as if artificial life were not also natural. The smoothest curled courtier in the boudoirs of a palace has an animal nature, rude and aboriginal as a white bear, omnipotent to its own ends, and is directly related, there amid essences and billets-doux, to Himmaleh mountain-chains, and the axis of the globe. If we consider how much we are nature's, we need not be superstitious about town, as if that terrific or beneficent force did not find us there also, and fashion cities. Nature who made the mason, made the house. We may easily hear too much of rural influences. The cool disengaged air of natural objects, makes them enviable to us, chafed and irritable creatures with red faces, and we think we shall be as grand as they, if we camp out and eat roots; but let us be men instead of woodchucks, and the oak and the elm shall gladly serve us, though we sit in chairs of ivory on carpets of silk.—R. W. Emerson, essay on "Nature."

The Pseudomath

TOBIAS DANTZIG

Dr. Dantzig graduated from the Sorbonne in 1909 with the degree of Licencié es Sciences and obtained his doctorate from Indiana University in 1917. He taught at Indiana, Columbia, Johns Hopkins, and the University of Maryland. At the latter university, he was head of the Department of Mathematics from 1932 until his retirement in 1946. On numerous occasions he has acted as consultant for several industrial concerns and the U.S. Government. He is the author of Number, the Language of Science, *the fourth edition of which has just appeared, of* Poincaré, Critic of Crisis, *and of* The Bequest of the Greeks, *which is being published by Scribner's and of which this article is Chapter Six.*

AMONG the imposing array of problems that have graced mathematics during its long and eventful history, there is a small group that has exerted a peculiar fascination on the amateur. To this group belong such famous problems of geometry as trisection and squaring of the circle; here also belongs the Euclidean postulate of parallels. Many other problems may be listed under this head; of these, I shall mention only the Fermat problem: to demonstrate that the equation $x^n + y^n = z^n$ has no solutions in whole numbers, so long as n itself is an integer greater than 2.

While the difficulties inherent in these problems can be met only by the resources of modern algebra and analysis, their preliminary formulation requires neither the exotic symbolism nor the weird terminology that obscure to the layman so many mathematical questions. Thus, whether the issue be a construction or a proof, the aims of these problems appear clear-cut and direct, even to those who possess little mathematical training or insight. This tantalizing simplicity has deceived many an amateur, with the result that no end of "solutions" have appeared, one as pretentious and as preposterous as the other.

While the amateur receives but little encouragement from the orthodox mathematician—a circumstance that he promptly attributes to professional jealousy—he finds the newspaper editor much more amenable to reason. In fact, some papers have regarded these achievements important enough to be featured as front-page news; others even have gone so far as to herald in glaring headlines that such or such an age-old problem, which has defied the efforts of countless generations of professional mathematicians, has in this day and age been completely solved by a nonprofessional. In this manner, the amateur may gain considerable notoriety; unfortunately, his glory is soon eclipsed, when a competing amateur with a conflicting solution of the same age-old problem, manages to gain the ear of another equally credulous editor. It is by dint of such publicity that the "famous" problems are daily gaining in fame, to the amusement of the expert and the confusion of the public.

These problems have played a considerable role in the history of mathematics. Not that they were key-problems, in the sense that without their exhaustive solutions the disciplines in which they arose could not have progressed. No, their role can best be compared with that of a catalytic agent which precipitates chemical action without participating in it. Thus, these problems have been responsible for the invention of many a new method, and more often than not, whole new disciplines have followed in their wake. As in the parable of the vineyard, the heirs failed to unearth the gold after laboriously plowing up the estate; yet, the loosened soil yielded a harvest that exceeded in wealth the anticipated treasure.

The ancient problems of trisection of an angle and duplication of a cube have, in modern times, led to the theory of equations and have been indirectly responsible for the introduction of the exceedingly important concept of *group*. The attempts to square the circle led to the discovery of *transcendentals*; the efforts to prove Fermat's theorem resulted in the theory of *ideals*; the failures to demonstrate the postulate of parallels culminated in the discovery of the *non-Euclidean* geometries, without which the theory of *relativity* would be unthinkable.

Of all these developments the ambitious amateur is, of course, wholly unaware. Indeed, he is, as a rule, not interested in developments that require the study of the work of others. Sufficient unto him is to know that the problem which he tackles has not yet been solved, or that it has been declared impossible by professional mathematicians. For the rest, he trusts in God and in his own powers or prowess.

It has fallen to my lot to come in contact with many of these individuals. I say this in no spirit of complaint, for, whatever inconvenience or irritation they may have caused me has been amply rewarded by the experience that I gained while studying their unusual turn of mind. Indeed, I hoped at one time to use the accumulated material for an essay *on the pathology of human reasoning*. As years go by, however, it is becoming increasingly doubtful that I shall ever have the leisure to engage in such a project. Accordingly, I decided to present some of the material here.

While the mental kinks of these individuals are to mathematicians little more than objects of passing curiostiy, the same should not be true of psychiatrists, more particularly of those who specialize in the study of megalomania. Indeed, I cherish the hope that among my readers there may be some such specialist who, stimulated by these casual remarks, will undertake a scientific investigation in this field which, to my knowledge, has not even been touched by the alienist.

It will be convenient to designate this specimen of humanity by a special name. The term *circle-squarer* is obviously misleading, for rarely do these individuals confine their efforts to this one classical problem. More often than not, they regard any mathematical problem—or any problem, for that matter—as particularly adopted to their talents, provided only that experts have failed to solve it or have reached negative results in its regard.

I propose to call these persons *pseudomaths,* a term coined by Augustus De Morgan. A substantial portion of his *Budget of Paradoxes* was devoted to the study of these individuals and their fallacies. Of the obsession with which the species is afflicted De Morgan has this to say:

> The pseudomath is a person who handles mathematics as the monkey handled the razor. The creature tried to shave himself, as he had seen his master do; but not having any notion of the angle at which the razor was to be held, he cut his own throat. He never tried again, poor animal! But the pseudomath keeps to his work, proclaims himself cleanshaved, and all the rest of the world hairy.
>
> The feeling which tempts him to these problems is that which, in romance, made it impossible for a knight to pass a castle which belonged to a giant or an enchanter. This rinderpest of geometry cannot be cured when once it has seated itself in the system. All that can be done is to apply what the learned call prophylactics to those who are yet sound. When once the virus gets into the brain, the victim goes round the flame like a moth—first one way and then the other, beginning again where he ended, and ending where he began.

The pseudomaths come from all strata of society and all walks of life. While the male of the species predominates, women too have entered the race. In fact, I have noticed of late that the number of feminine pseudomaths is on the increase, which, perhaps, is but a symptom of the gradual emancipation of the fair sex. Most countries, races, creeds, professions, and crafts are represented; my own list includes farmers and army officers; bankers, brokers, and merchants; realtors and prospectors; doctors, dentists, and lawyers; engineers, artists, and artisans; teachers, preachers, and even a college president.

How large is their number? The question cannot be answered with any degree of accuracy. There are no societies of pseudomaths, which is not surprising, since every pseudomath, being in sole possession of the eternal truth, views every other as an imposter and a fraud. In the absence of such rosters, any estimate is but a guess; my own, based on personal contacts and correspondence, is that, in this country alone, their number must run into many thousands.

In spite of the fact that pseudomaths are being recruited from so many different occupations and classes, they exhibit a remarkable similarity in their methods of approach to a problem as well as in the strategy they use to obtain recognition. When given an opportunity to defend their contentions, every one of the pseudomaths who has come under my observation used the same tactics, which may be best qualified as a policy of attrition. With tiresome laboriousness and endless detail, each pseudomath would demonstrate the obvious steps in his reasoning; but having arrived at the critical point, he would pass over it with the utmost speed. Indeed, I have found in my dealings with pseudomaths that I can save myself a great deal of labor by just listening listlessly and without the slightest interruption to their drone, patiently awaiting the imminent slur.

The variety of their interests is unbelivably great. Thus, the announcement in 1907 of the Wolfskehl prize for the first solution of the Fermat problem found such a tremendous response from the pseudomaths of the world that the handling of the correspondence became a gigantic task. The advent of the theory of relativitv has deviated the efforts of many into this new channel, with the result that every so often we are graced with a new refutation of Einstein. Quite often I receive letters from some individual who has discovered a kinship between phenomena which to the benighted scientist appear worlds apart; one, possessed by a truly universal spirit, has succeeded in uniting into a single synthesis the Euclidean postulate of parallels and the

quadrature of the circle, the Fermat problem and perpetual motion, the principle of relativity and the existence of the Deity, the quantum theory of the atom, forecasts of the stock market, the abolition of wars, the solution of the economic depression, and the liberation of mankind from the Communist scourge—to mention but a few of the achievements he claims.

The dogged perseverance of pseudomaths defies all description. They seem to thrive on abuse, discouragement, and ridicule. They speak of their undying devotion to truth. It cannot be denied that no pseudomath has ever derived material benefit from his discoveries, while most of them continually sacrifice wealth and position in their efforts to gain recognition. I do not believe that they are actuated by greed; in fact, I have a lurking suspicion that even those pseudomaths who have tried for the Wolfskehl prize of 100,000 marks were motivated more by the desire to justify in the eyes of their kin and friends their fruitless efforts of many years than by any hope of winning the prize.

To my mind, the dominating motive that sustains them in the face of all failures is an inordinate craving for publicity. To attain this end, they will stoop before no humiliation. One of the most remarkable instances of this kind is the case of one, James Smith, a merchant of Liverpool, who flourished in the sixties of the last century. Smith spent half of his life and a considerable fortune in defending his method of squaring the circle, a method which, with all irrelevancies removed, amounted to the declaration that the ratio of the circumference to the diameter of a circle was equal to exactly 25/8. He engaged in a voluminous correspondence with the leading British mathematicians of his time, among whom were such outstanding men as William Rowan Hamilton, Stokes, Clifford, De Morgan. They all began by trying to set him right; they all ended by giving it up as a bad job. Some of the replies of these men were so devastating that any sane man would have immediately destroyed them for fear that they might see the light of day. Not James Smith! At a price to himself that must have amounted to a small fortune, he published the whole correspondence and distributed the book free of charge to friend and foe alike. This volume of 500-odd pages is a human document of inestimable value to a psychopathologist.

There is a term used in physics to designate an effect that persists after the generating cause has ceased to act, as it occurs, for instance, in elastic or magnetic phenomena. Such a residual aftereffect is known as *hysteresis* and could be aptly applied to many phenomena in the history of science, and of culture more generally.

The pseudomath is a case in point. Far from being a phenomenon peculiar to our own times, he is as old as mathematics and, in a certain sense, even older. Indeed, just as astronomy was preceded by astrology, and chemistry by alchemy, so was mathematics preceded by *pseudomathematics.* Thus, in the *prelogical* period of mathematics, when it was an empirical science as yet, all its adepts were pseudomaths, more or less. The deductive method has put an end to the usefulness of the pseudomath, yet he shall long persist as a sort of hysteresis.

That the species was already a problem in ancient Greece, even as far back as the days of Pericles, may be judged from a scene that occurs in Aristophanes' comedy *The Birds.* Meton, an Athenian surveyor—and a pseudomath, if there ever was one—demands admission to the Bird-State. When requested to give his qualifications, he offers to parcel off the atmosphere into acres and to square the circle by means of a straightedge. He is refused admittance and asked to move on. He insists on knowing why, whereupon the following conversation takes place:

> What danger is there? Is discord raging here?
> No, Not at all!
> What is the matter then?
> In perfect concord are we resolved to kick out every humbug.

It is interesting to note that 2400 years ago Aristophanes had a proper appreciation of such amateurish efforts; whereas editors of some of our modern dailies rarely miss a chance to blazon forth to the world that on such and such a date such and such a nonprofessional has at last solved a problem that has baffled professional mathematicians for nearly 3000 years.

The Dark Ages may be viewed as a sort of resurrection of the prelogical period. What little science was cultivated then was so hopelessly mixed with pseudoscientific ideas that the task of a modern historian who deals with this period may well be compared with that of unscrambling an omelet. Mathematics was no exception; the "Famous Problems" were approached in the same spirit as the search for the philosopher's stone or for the elixir of life. In fact, it was held by many that the quadrature of the circle would open the door to many such mysteries. Some of the most absurd solutions of the "Famous Problems" date from this period; futhermore, most of the fallacies of the modern pseudomath may be found in medieval literature. That there is little new under the sun applies to fallacies even more than it does to truth.

With the advent of modern times, there was an unprecedented increase in pseudomathematical ac-

tivity. During the 18th century, all scientific academies of Europe saw themselves besieged by circle-squarers, trisectors, duplicators, and *perpetuum mobile* designers, loudly clamoring for recognition of their epoch-making achievements. In the second half of that century, the nuisance had become so unbearable that, one by one, the academies were forced to discontinue the examination of the proposed solutions. The first to inaugurate this policy was the French Academy. To its published resolution, there was attached an explanatory note, written by the great Condorcet. The following are excerpts from this interesting document:

> The Academy has resolved this year not to examine in the future any solution of the problems of the doubling of the cube, the trisection of the angle and the squaring of the circle, or of any machine which lays claim to perpetual motion. . . .
>
> We have thought it to be our duty to account for the reasons which have led the Academy to adopt this decision. . . .
>
> An experience extending over more than seventy years has demonstrated that those who send in solutions of these problems understand neither their nature nor their difficulties, that none of the methods employed by them could ever lead to solutions of these problems, even were such solutions attainable. This long experience has convinced the Academy of the little value that would accrue to science, were the examination of these pretended solutions to be continued.
>
> There are still other considerations that have determined this decision. A popular rumor has it that the Government has promised considerable rewards to one who would first solve the problem of squaring the circle. . . . On the strength of this rumor, a multitude of people, much greater than is commonly believed, have given up useful work to devote their time to this problem which often they do not understand, and for which none of them possess the requisite preparation. Nothing could therefore serve better to discourage these people than this declaration of the Academy. Some of these individuals, being unfortunate enough to believe that they have been successful, have refused to listen to the criticism of Geometers, often because they could not understand it, and have finished by accusing the examiners of envy and bad faith. . . .
>
> The folly of the Circle-Squarers would result in no greater inconvenience than the loss of their own time at the expense of their families, were it not that such folly is, unfortunately, never confined to one subject, since the habit of fallacious reasoning—even as that of correct reasoning—has a tendency to increase, as it has happened in more than one case. Moreover, to account for the singular fact that, without studying the subject, they have arrived at solutions which the most famous scholars have vainly sought, they persuade themselves that they are under the special protection of Providence, and from this there is but one step to the belief that any combination of ideas, however strange, that may occur to them are so many inspirations. Humane consideration therefore demanded that the Academy, persuaded of the uselessness of such examinations, should seek to offset by public announcement a popular opinion that has been detrimental to so many families. . . .
>
> Such were the principal reasons that have determined the Academy's decision. The declaration that it will not engage in the future in this task is tantamount to a declaration that it regards as futile the work of those who engage in it. It has been often said that, while seeking chimerical solutions, one may discover a useful truth. Such opinions might have been valid in days when the methods for discovering truth were equally unknown in all fields of endeavor; to-day, when these methods are known, it is more than probable that the surest way to find truth is to seek it. . . .

This long-forgotten document reads as though it had been written yesterday, and not 180 years ago. What effect did it have? Well, if the aim of the Academicians was to spare the scientific societies the annoyance incident to the examination of these solutions, then they have been more than successful. Soon, other academies followed suit, until today it is impossible for a pseudomath to get a hearing before any reputable scientific organization. On the other hand, if the French Academy had hoped to free the world from the pseudomath, then, it must be admitted, that the document was a miserable failure. For, I dare say, there are more pseudomaths today than at any time in history; besides, their number increases by leaps and bounds from year to year. And the negative attitude of the scientific world, far from dampening their ardor, only makes them more militant.

All this in spite of the fact that, in the course of the last century, all the problems reviewed by Condorcet were brought to a successful conclusion. For the pseudomath, time has stood still. The solutions of these problems may appear to the mathematician ever so profound and far-reaching; to the pseudomath they are but mockeries, delusions, and snares, to use an expression of that king-circle-squarer, James Smith.

And, strange as it may seem, these sentiments are shared by the public at large. Indeed, the solutions that modern mathematics has offered to the "Famous Problems" are not solutions at all, as the term is usually understood. They do not culminate in a

definite recipe prescribing certain traditional operations on certain traditional ingredients; they culminate in the declaration that such a recipe is unattainable. Moreover, the reasoning that leads to these negative conclusions involves consideration of algebra and analysis, which appear to the layman as irrelevant and, therefore, wholly unconvincing. The pseudomath brushes all such reasoning away with a contemptuous smile, branding it professional subterfuge that aims at covering the orthodox mathematician's incompetence behind a smoke screen of symbols and technicalities.

And so the merry-go-round spins on. Each year sees new solutions of the ancient problems, which the benighted mathematician has long ago stricken off his list as solved. Our own century has been particularly prolific: dozens of solutions have been announced in our daily press. One of these received extraordinary publicity. It concerned the trisection problem and was the discovery of a president of an American Catholic college. Substantially, the Reverend Father's solution consisted in his trebling an angle and then exclaiming enthusiastically: "Behold the whole, and then behold the part!" Judging from the numerous inquiries I have received concerning it, the Pater's fame must have traveled very far. He was, in fact, so encouraged by the reception accorded to his achievement that he decided to continue his researches and subsequently enriched the world with a book in which he proved the Euclidean postulate of parallels and, simultaneously, annihilated the impious Einstein.

I shall conclude this chapter by recording three conversations that I had, all in connection with this ecclesiastic trisection. My interlocutors were all college graduates. The first, a successful engineer, after listening to my explanation with ill-concealed irritation, interrupted me with a sneer:

> The dogmatism of you fellows makes me tired. It reminds me of those experts who only 30-odd years ago maintained that flying was impossible. Granted that the priest's construction is wrong, as were the other solutions before him, what of it? To me, it only means that the problem is a challenge to human ingenuity. I am confident that some day solutions to these problems will be found, and that, when they are found, it will not be along the beaten paths which the professional mathematician is likely to follow.

The second, a literary man with philosophical aspirations, said:

> I cannot agree with your conclusions. It seems to me that mathematicians lose sight of one incontrovertible truth, namely, that *if a problem can be formulated in certain terms, it can be solved in the same terms.* Now, you admit that all the problems which you have mentioned can be formulated in terms of straight lines and circles; by the same token, their solutions should require no other lines.

The third, a realtor, listened to my comments with complacent mistrust. By way of changing the topic, or perhaps with a more subtle intent, he remarked that the college which the Reverend Father was heading possessed a first-class football team.

Unpetrified

On the wet, hard beach
where the sandpipers run
there's a pattern of ferns

Just out of reach
of waves at fun,
where hot sun burns—

A pattern of ferns
dainty, crossed,
where the birds run wide
with dips and turns.

It will all be lost
at the next high tide. . . .

RACHEL GRAHAM

Computers: 1954

MINA REES

Dr. Rees, who is dean of faculty at Hunter College in New York, received her training at Hunter and the University of Chicago. During World War II, she served as technical aide in the Applied Mathematics Panel, National Defense Research Committee. For her war work, she was awarded the King's Medal for Service in the Cause of Freedom and the President's Certificate of Merit. Between the close of the war and 1953, Dr. Rees organized the mathematics program of the Office of Naval Research and was director of its Mathematical Sciences Division, a post that included central responsibility for the Navy's computer program.

IN recent newspaper stories, there have been some miraculous-sounding tales of the uses to which electronic computers have been put. In this article (*1*), I shall try to put these accounts into perspective by giving some impression of the state of the art in the technology of construction and in the science of use of digital computers. I shall also try to give a little more detail about some of the applications that have excited public interest and to indicate other directions in which applications are being developed and sought.

The newspaper account that most recently stirred interest among academic people was the report of the demonstration of the so-called "translation machine." Although the reader was informed that it is not yet possible to insert a Russian book at one end and come out with an English book at the other, Leon Dostert of the Georgetown University Institute of Languages and Linguistics did predict that "five, perhaps three years hence, interlingual meaning conversion by electronic process in important functional areas of several languages may well be an accomplished fact."

Another planned use of an electronic brain was reported on Dec. 13, 1953, when an announcement was made of a contract awarded to the Raytheon Corporation to develop specially designed "brains" for use in controlling the Missouri River and of a concurrent study at New York University on the problem of flood control. And on Nov. 29, 1953, there was an article on weather prediction by means of a large-scale electronic computer. These were front page *New York Times* articles. There are also the minor articles that occur almost weekly, such as the one, with headline "Blast Off for Mars," which reported that the Hayden Planetarium in New York had borrowed an ELECOM so that visitors might determine the best type of space flight to take to the planet of their choice.

Let me begin by giving some idea of the number, type, and location of the electronic digital computers now in operation, or soon to be completed, and of the principal characteristics of these machines. There are more than 70 in the United States, somewhat more than half in current operation, and the rest soon to be completed. There are two major companies manufacturing what I shall refer to as *large* machines in a sense that I shall try to explain, and about a score of other companies manufacturing machines of moderate size. Abroad there are 12 machines in England, five in Germany, three in Japan, and one or two in Belgium, Holland, Sweden, Norway, France, and Australia, as well as Canada. England has two companies that are manufacturing the machines for sale.

Now, what do we mean by a large machine and by a machine of moderate size? I shall not stop to review the essential elements in the anatomy of these machines, since I believe this material has, by now, acquired a certain familiarity; but it may be worth noting that the use of the term *anatomy* and references to the "organs" of the machine constitute a recognition of the similarity between the functions performed by a machine and those performed by a human calculator or controller (in the cybernetic sense). A computer incorporates into its mechanism elements that can handle all the operations involved in a computation from the time that computation is explicitly formulated. But, to quote Claude Shannon, "a digital computer must be instructed in words of one micro-syllable." A short time ago, when I told, in a talk on computers before the Research Society of America, the detailed steps necessary to make the computer evaluate the expression $(3x + 10)$ for several values of x, the very large number of instructions needed by the machine to make this simple computation was a source of real surprise to most of the audience.

The new computers can be instructed to perform any operation that has been reduced completely to

Fig. 1. The IBM electronic data-processing machine (701). One of the machines considered for the Joint Numerical Weather Prediction Unit.

the elementary arithmetic operations, but the capacity of a given general-purpose computer to handle a particular problem is largely determined by the number of additions, subtractions, multiplications, and divisions it is asked to perform. If the machine's so-called "memory" is large enough to remember all the instructions it must be given and all the numbers on which it must operate, and if it is fast enough to find an answer in a reasonable time—say a few hours, or a few weeks, or a few months, depending on the problem—then the machine is able to handle the problem. It is in this sense that some machines are large in being able to handle problems with large numbers of operations, and others are of moderate size.

The large machines that are for sale, the UNIVAC, the IBM 701, the ERA 1103, and the Ferranti machine in England, are all general-purpose machines that can solve substantially any type of problem; the last three have memories that combine electrostatic tubes and magnetic drums and tapes, while the UNIVAC uses mercury delay lines and magnetic tapes. The machines that are being built to handle business problems are, for the most part, moderate in size and rely on magnetic drums for memory elements. Some of them are so designed that they can handle only certain types of problems —they are special-purpose, and the programs they can follow are built in, not programmed in, for each type of problem. In this sense, a speedometer (which is an analog machine) is special-purpose.

The machines that have caught recent headlines are the large, automatically sequenced general-purpose machines. Let us explore a little each of the afore-mentioned problems and look behind the headlines. Consider first the meteorology problem. The Air Force and the Navy have, for several years, been supporting work aimed at securing faster and more reliable operational weather forecasting. The essential difficulty in applying fast electronic computers to this problem has been to obtain a mathematical model of the atmosphere that represents the physical reality closely enough so that its predictions are useful and will, at the same time, be of a size (in the sense in which I have defined the term) to make its solution realistic.

Studies have been under way for some years under J. G. Charney and John von Neumann at the Institute for Advanced Study. Last spring, it appeared that their so-called "three-layer" model would predict most of the interesting weather phenomena (*2*); and they are now working on a five-layer model. This means that, in the numerical solution of the differential equations describing the motion of the atmosphere, five grid points would be used in the vertical. The horizontal finite difference lattice contains no less than 20×20 grid points. The equations are strongly nonlinear, but the three-layer model uses a quasi-linear form. The time-consuming process involves the calculation of the coefficients from observed data, and then the solution of the finite difference equations by a systematic, iterative procedure. This would be done 48 times for each 24-hr prediction.

One of the difficulties in operational prediction is adequate data-processing methods. For several months last year, we were in the absurd predicament of being able to solve the weather equations

in about 3 hr while the processing of the observed data for a 24-hr period took about 3 wk. At present, data preparation is done by hand, and this is not very satisfactory with respect to either speed or precision. A logical method that would put the burden of data processing on the machine is under development.

In view of the progress that has been made, a decision was reached last fall by the Navy, Air Force, and Weather Bureau to proceed with the establishment of a Joint Numerical Weather Prediction Unit; and the problem of selecting an appropriate machine for this purpose is now confronting responsible authorities. The choice is complicated by the fact that a problem of much larger size than the current one will require solution as soon as the more reliable five- (or even seven-) layer model has been developed and as soon as a satisfactory method for processing the data exists. The choice of the machines is further complicated by the fact that a rapid output unit is needed to facilitate the examination of intermediate results during operational prediction. It is also true that output in the form of a punched tape or card is needed to facilitate teletype transmission of results to users of weather information. Fast input and output are essential to handle data processing internally, using teletype reports directly.

In trying to choose between the two machines that were large enough and fast enough to be considered competitive, the responsible group ran the same problems on the IBM 701 and the ERA 1103 (Fig. 1). The problems chosen for solution were three numerical forecasts each covering a 24-hr period and based on the quasi-linear three-layer model. Each group was asked to solve a set of three nonlinear differential equations for three different sets of initial conditions. It is of some interest that, while programming the problem for one machine took about 6 man-weeks, debugging the code took 15 hr of machine time. Once the code was debugged, the three problems were run the same evening. The over-all running time per problem was about 30 min. This does not count the time required to print a readable record from the output tapes; but the 30 min does include about 13 min punching time which could not be interlaced with the calculation. It does not include read-in time.

The program for the other machine, including check-hand calculations, was completed in about 17 man-weeks by a programmer without experience; and the debugging consumed about 50 man-hours. The over-all running time, including input and printing time, was 59 min. This second machine was programmed to provide duplication checks for most of the logical operations. But more important than the actual computing time, for this particular application, is the fact that the second machine has fast input and output, critical in processing the amount of data necessary for weather forecasting, and that the output can be translated mechanically into a pressure-level map, important for weather forecasts.

However, either of these machines is capable of handling the problem; and we have, after about 8 yr of scientific and engineering effort, reached the point where the Weather Bureau, the Air Force, and the Navy (when they demand a machine that really operates) have two machines from which to choose. They expect a machine to be making operational tests within a year.

The status of the flood-control problem is quite different. Although it is expected that a special-purpose machine will be built to handle the computations required as a basis for making flood-control decisions, the formulation of what appears to be a satisfactory mathematical model has only recently been completed at New York University (using a linearization of the basic flow equations). This is currently being subjected to the test of actual computation. The Corps of Engineers' work on dam construction proceeds, and Raytheon is also studying the problem—but a working special-purpose machine within a year is not to be expected.

With regard to the translation problem, the situation is still different. This problem has been under study for several years, and the report last January was one of several that might be given. At the Institute for Numerical Analysis of the National Bureau of Standards, a study was conducted some years ago, with Rockefeller Foundation support, that produced, among other things, a report (3) from which I quote one passage that discusses elements similar to those of many problems for which one seeks machine solutions. Oswald and Fletcher say,

> Our procedures were purely pragmatic. We began by reexamining the processes by which the reader analyzes the syntactical relationship to one another of words or word blocks. Then, after working out a code for the identification of syntactical relationships, we proceeded to reduce the analytical processes to mechanical routines. Some of our routines actually reproduce processes of grammatical analysis; others substitute processes which use indicia to which the reader pays little attention (for example, capitalization of the first word of a sentence), but which can constitute marks of recognition for a machine . . . . we found that much of our investigation led to the rediscovery of things familiar but partially forgotten, which is indeed for-

tunate, for this means that some form of coding system can be applied without much process of refinement to any language whose syntax has been adequately analyzed.

This underlines the first and most important task of anyone who wishes to apply an automatic computer to the solution of his problems. He must first analyze the problem into tiny steps, each capable of being translated into machine language, and this often leads to the rediscovery of things familiar but partially forgotten. This analysis was the prime task of the Georgetown Institute of Languages and Linguistics when they undertook the task of using the IBM 701 computer for the translation of Russian. The demonstration of automatic Russian to English translation on January 7 of this year represented the culmination of a year and a half of cooperative effort between the Georgetown University Institute and the IBM Corporation. The linguistic studies

Table 1. Rules of operational syntax to accompany Fig. 2.

Rule 1: Rearrangement. If first code is 110, is third code associated with preceding complete word equal to 21? If so, reverse order of appearance of words in output (that is, word carrying 21 should follow that carrying 110); otherwise, retain order. In both cases, English equivalent I associated with 110 is adopted.

Rule 2: Choice—Following Text. If first code is 121, is second code of the following complete, subdivided, or partial (root or ending) word equal to 221 or 222? If it is 221, adopt English equivalent I of word carrying 121; if it is 222, adopt English equivalent II. In both cases, retain order of appearance of output words.

Rule 3: Choice—Rearrangement. If first code is 131, is third code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to 23? If so, adopt English equivalent II of word carrying 131 and retain order of appearance of words in output: if not, adopt English equivalent I and reverse order of appearance of words in output.

Rule 4: Choice—Previous Text. If first code is 141, is second code of preceding complete word or either portion (root or ending) of preceding subdivided word equal to 241 or 242? If it is 241, adopt English equivalent I of word carrying 141; if it is 242, adopt English equivalent II. In both cases, retain order of appearance of words in output.

Rule 5: Choice—Omission. If first code is 151, is third code of following complete word or either portion (root or ending) of following subdivided word equal to 25? If so, adopt English equivalent II of word carrying 151; if not, adopt English equivalent I. In both cases, retain order of appearance of words in output.

Rule 6: Subdivision. If first code associated with a Russian dictionary word is ***, then adopt English equivalent I of alternative English language equivalents, retaining order of appearance of output with respect to previous word.

SOURCE SENTENCE: vyelyichyina ugla opryedyelyayetsya otnoshyenyiyem dlyini dugi k radyiusu.

ANALYSIS:

RUSSIAN WORD	ENGLISH EQUIVALENTS I	ENGLISH EQUIVALENTS II	1st CODE	2nd CODE	3rd CODE	RULE NO.
vyelyichyina	magnitude	- - -	***	***	**	6
ugl-	coal	angle	121	***	25	2
-a	of	- - -	131	222	25	3
opryedyelyayetsya	is determined	- - -	***	***	**	6
otnoshyenyi-	relation	the relation	151	***	**	5
-yem	by	- - -	131	***	**	3
dlyin-	length	- - -	***	***	**	6
-i	of	- - -	131	***	25	3
dug-	arc	- - -	***	***	**	6
-i	of	- - -	131	***	25	3
k	to	for	121	***	23	2
radyius-	radius	- - -	***	221	**	6
-u	to	- - -	131	***	**	3

TARGET SENTENCE: magnitude of angle is determined by the relation of length of arc to radius.

Fig. 2. English equivalents of Russian words and code numbers used to translate a Russian sentence. See Table 1 for rules of operational syntax.

were carried on by the staff of the Institute under the direction of Leon Dostert. The procedures they devised were translated by IBM coders into language the machine could understand.

When translation studies reach the point where a practical translation machine can be devised, we may expect that a specialized machine will be designed for the purpose. The present study merely sought to demonstrate that translation can be handled mechanically. The demonstration was performed on IBM's most advanced general-purpose computer—a machine of which more than 10 copies are now in operation in various parts of the country.

The demonstration was performed with a 250-word vocabulary stored in the computer's memory. Each Russian word was listed with one or two English equivalents and three code numbers. The dictionary included various word endings as well as the words; and the code numbers, in conjunction with six rules of syntax, were used to determine from the code numbers of neighboring words the English equivalent that was to be used and whether the word order needed rearrangement (Table 1, Fig. 2).

The magnetic drum of the computer was used for holding the dictionary. In the test problem, the magnetic tapes were not used; but they present an inviting storage for specialized vocabularies in various technical fields, if the procedures demonstrated are ever put to use in the manner predicted by Dostert. The high-speed cathode-ray tube memory was used to hold the program. But for a translation problem of substantial real usefulness, the high-

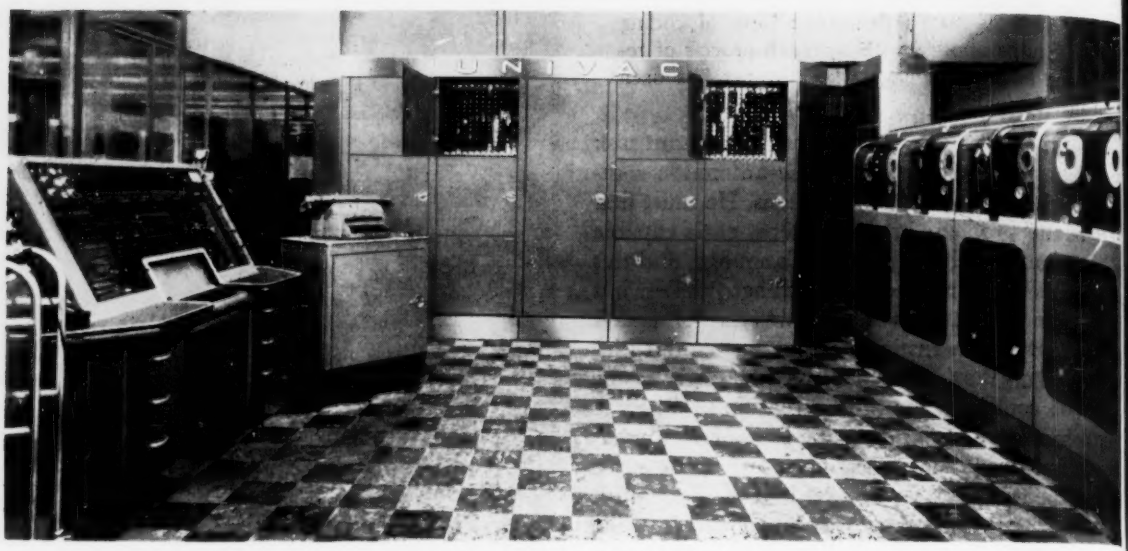

Fig. 3. The UNIVAC.

speed memory of current machines would be entirely inadequate, because such a problem would require something like 100 rules of syntax, a good many code numbers associated with each word, several possible English equivalents for each word, and a sophisticated routine for selecting the most appropriate equivalent. It was because of the extreme complications involved in making any such study that the original demonstration employed only a 250-word vocabulary. Essentially, a careful analysis must be made of every possible use of every variation of every word in the vocabulary, and a code must be devised for each word-ending that makes possible the automatic recognition of each different situation.

The Georgetown-IBM program is more sophisticated than anything that has grown out of previous attempts at mechanical translation. Russian words that must be omitted in English are left out in the translations, while English words that are omitted in Russian are automatically supplied. The present program stops the machine when it encounters a word not in its vocabulary or a construction not governed by its rules of syntax. It should be relatively easy to provide a program that will print out, untranslated, an unknown Russian word and translate word for word where the syntax is strange.

Any further developments of mechanical translation will require a considerable amount of linguistic research. Extensive statistics must be gathered to determine the frequencies and various possible translations of each word in various contexts. Technical vocabulary must be studied and usage cataloged. Efficient categorization of words, endings, and relationships between words must be made. Whether enough skilled people can be found who are sufficiently interested and devoted to dedicate themselves to this task remains to be seen. The possibility of bringing this project to fruition within the predicted 3 to 5 yr depends critically on the carrying out of these tasks (*4*).

Some of the intriguing applications that have come out of the vast engineering effort of the last decade have been discussed in foregoing paragraphs. We should not forget, of course, the more familiar, but quite as important, work in which these machines are engaged in aircraft factories, defense establishments, and universities. It will be remembered that, at election time, one of the giants, the UNIVAC, failed to convince its audience when it forecast the results too well for belief (Fig. 3). But these great machines, and their successors that are just around the corner, are finding more trusting adherents in many new applications, and it is inviting to speculate on their role in reshaping our industrial and scientific life. In discussing the future, I shall try to limit my attention to applications where there are some threads into the present to point the direction of future developments, in spite of the fact that dreams of revolutionary developments are singularly appealing—and often justified.

In the immediate future, we may expect smaller and faster machines with bigger appetites—ability to handle more complex problems more quickly. The devices that will make such machines possible—the transistor, the magnetic-core memory, the many types of miniaturized components—are well understood. A magnetic-core memory has recently been put into use in the Whirlwind Machine at

the Massachusetts Institute of Technology; and the development of machines using transistors is well advanced.

In the immediate future, too, some of the scientific problems that have not yet been studied or have been only partially resolved because of the limitations of present machines will be undertaken. I have given an account of the present status of operational numerical weather forecasting. There are other scientific domains in which experiments are impossible where we may expect digital computers to contribute understanding that is otherwise denied to us. In the study of great explosions—stellar explosions that may have taken place millions of years ago and atomic explosions that are taking place in our own time—significant understanding can be reached by numerical experimentation with high-speed machines.

It may be worth mentioning that about one-fourth of the large computers in operation in this country are used almost exclusively by the Atomic Energy Commission. Other large computers have been put into the service of many parts of the defense establishment and are being adopted by large industrial organizations. Commonwealth Edison of Edgerton, Ill., is considering buying a UNIVAC, if only Remington Rand and its subsidiaries can solve the problem of printing on both sides of the card on which Commonwealth Edison wishes to bill its utilities; and the Franklin Life Insurance Company of Springfield, Ill., has one on order. Other insurance companies are also introducing computers; Metropolitan Life has a UNIVAC on order.

In Sept. 1952, the Society of Actuaries had a special meeting in New York to hear the report of its Committee on New Recording Means and Computing Devices. I found the report an interesting document, because it made a very careful and detailed study of current procedures in an insurance company and recommended that very serious consideration be given to the usefulness of computers, recognizing certain salient questions. For example, the report says,

> With such a computer it appears possible to arrange insurance work in such a way that large volumes of work which are now done at different times and in different places can be brought together to be done at one time. The consolidated approach is one way of accomplishing this. We can begin to get a picture of what a plan of this type would mean from the fact that, in at least one company, ten separate policy files are being maintained where only three would be necessary under the consolidated approach . . . . the production of many of the basic statistics needed for financial reports can well be done at the same place and at the same time that individual policy figures are being determined . . . . the insistence on the retention of these three card files merely reflects the attitude that we are not quite ready yet to accept the idea that basic records can be safely entrusted to tape. We probably will not be ready until a fairly extended test period of day-to-day use has been fully satisfied.

Clearly some reorganization of the administrative structure of the company is needed if a machine is to be used at all economically; and several insurance companies are embarking on such reorganizations.

The problems involved in the use of computers for record keeping are interesting to speculate upon, for the legal aspects of the questions become intriguing. Will the courts accept what the computer says as evidence in litigation, particularly when the memory has been erased (as in the case of magnetic memory) or lost (as in the case of electrostatic tubes)?

As we pass on to a consideration of some of the other uses of computers in industry, it may be well to stop for a moment to recognize one characteristic that usually marks a sharp distinction between a scientific problem, for which most of these computers were originally developed, and a business problem. A scientific problem usually involves a great deal of computation on relatively small amounts of data. Many business problems, on the other hand, and many military and operational problems as well, are characterized by large amounts of data and relatively small amounts of computation. In this environment, as in the operational meteorology problem, the so-called "end-organs"—the input and output—are likely to become critical. The development of special input and output equipment for special problems is going on in several areas of interest.

It may be worth noting that the UNIVAC, originally developed for the Census Bureau's handling

PREMIUM NOTICE

NEW YORK LIFE INSURANCE COMPANY
Home Office: 51 Madison Avenue, New York 10, N. Y.

Please note that a payment will be due as described herein provided the policy is then in full force.

POLICY NUMBER 12345652A A12 DATE DUE 12 15 52

JOHN PAUL NYLIC
% JOHN P NYLIC JR
NEW YORK LIFE BLDG
51 MADISON AVENUE
NEW YORK 10 N Y

PREM $456789
LN INT 345678
DIV 91358
payment due 711109

RETAIN THIS NOTICE as your record of payment. A receipt will be sent if requested when payment is made.

Paid by Check No. _____ Date _____

SEE OTHER SIDE

Fig. 4. A premium notice prepared by a high-speed printer.

of large amounts of alphabetic and numerical data, is finding many applications in business. This spring UNIVAC is scheduled to take over a variety of accounting jobs at General Electric's Louisville plant where General Electric is bringing together its electric appliance manufacturing units in one place. The UNIVAC will undertake the preparation of payrolls, basing its computations on information stored in its memory concerning wage rates, overtime, and the various deductions that must be made. It will compile sales records and prepare bills. It is expected ultimately to be used to make sales analyses, to note regional shifts in the sales of various appliances, and to modify production accordingly.

Another inventory-control machine, manufactured by Engineering Research Associates, a subsidiary of Remington Rand, is a special-purpose machine for speed tallying. It has a primitive arithmetic organ, no program control, and a magnetic-drum memory. It is in operation at a Chicago mail-order house, John Plain, and it was used successfully during the last Christmas rush. It handles 90,000 tallies a day, keeping track of inventory on the 8000 items in the catalog.

Thus far only two commercial organizations, IBM and Remington Rand, have built large-scale machines that are being put to both scientific and business use. However, International Telemeter is currently engaged in the design and development of a machine to simplify the handling of bank checks. The degree of automatization that is realistic in large banks is difficult to determine. There are redundant human operations in the handling of checks that are deposited at branch banks and later forwarded to a central sorting unit. But a check is in itself the legal document on which payment is made, so that it is not sufficient to convey to the central place within the bank, or to other banks, the information that resides in the check. The check itself must be conveyed. International Telemeter is planning to attach to the check at the time of the first branch operation a standard strip or edge bearing the coded information derived from the check. After this has been done, machine devices can operate on this attached strip. The other essential bank operations—the keeping of permanent records on all transactions and the showing on demand of all operations performed on a depositor's account—can be handled with existing equipment.

Any realistic approach to the introduction of computers in going business concerns must start with the status quo and proceed by modest steps into the future. Many business concerns will find it a big task to tailor their office procedures to the use of computers. In many cases, the office procedures in use are not known in all their detail to any single member of the organization, and the first job is to find out exactly what is being done. This is not a trivial job, the early savings are elusive, and it will take real conviction as to the usefulness of the outcome to get the initial study under way. IBM has done a splendid job in smaller but comparable situations in introducing its small business machines; and this company can be expected to do a good job here. Remington Rand also has an excellent staff making analyses of the problems of potential users of their machines.

It is clear that in the relatively near future we shall see a notable expansion of business and manufacturing applications of digital machines, including automatic process control and other features of the "automatic factory."

References and Notes

1. Based on a speech delivered before the Illinois Institute of Technology chapter of Sigma Xi, Mar. 10, 1954.
2. J. G. Charney, "Numerical prediction of cyclogenesis," *Proc. Natl. Acad. Sci. U.S.* **40**, No. 2 (Feb. 1954).
3. V. A. Oswald, Jr., and S. L. Fletcher, Jr., "Proposals for the mechanical resolution of German syntax patterns," *Modern Language Forum* **36**, No. 3–4 (1951).
4. This account is based, in part, on an informal report by Nelson Blachman.

Advance information of the result of the Battle of Waterloo consolidated the Rothschild fortune. It is advance information, which may be of equal potential value, that research offers you.—ARTHUR D. LITTLE.

The Economics of Power Reactor Processing

D. E. FERGUSON

Mr. Ferguson is assistant section chief of the Chemical Development Section, Chemical Technology Division, at Oak Ridge National Laboratory and a member of the Homogenous Reactor Project of that Laboratory. He has been engaged in chemical process development in the atomic energy field since 1946, when he completed 2 years of active duty with the U.S. Navy. He received his engineering training at the Tennessee Polytechnic Institute and the University of Tennessee.

THE reason why chemical processing of power reactors is necessary has been well stated by David Lilienthal (*1*):

> When fission takes place energy is released . . . but something is left behind [*i.e.*, the fission products]. Inside the reactor, where all this takes place, the effect of these hot elements on the operation of the reactor is bad. Some of the new elements absorb neutrons readily, so that their effect is to quench the nuclear reaction. These fission products —the nuclear ashes—must be removed and the remaining nuclear fuel used again.

The chemical process, then, is designed to recover unspent fuel and unused raw material from fission products which would otherwise lower the efficiency of reactor operation.

If an atomic power facility is compared with a conventional power plant, the counterpart of the chemical process is the removal of flue gases and ashes from the furnace in order that combusion can proceed unhindered by these by-products. Beyond this, all similarity ends. The removal of flue gas and ashes from a furnace is essentially a physical process, whereas the separations associated with a nuclear reactor are basically chemical in nature, and disposal of wastes is only one of the three major purposes of the chemical process, since the process must also recover both fuel and raw material in a form suitable for return to the reactor.

There are three major features of this chemical separation that distinguish it from the common industrial inorganic chemical process, all of which greatly affect the economics of processing. The first of these is the presence of dangerous radioactivity (*2*). For this reason, a large percentage of the chemical operations must be carried out behind heavy shielding by remote control. In addition, elaborate safety precautions are necessary to protect personnel from accidentally coming into contact with dangerous radioactivity.

Another feature is the very high recovery, greater than 99 percent, necessary for economical operation (*2*).

The third feature is the high degree of separation —a factor of 10 million—of the fissionable material from fission products that is required to permit safe handling of the isolated product by personnel (*2*).

The problems introduced by these three characteristics of the chemical process require careful study in the design of both the chemical process and the nuclear reactor to make atomic power competitive with a conventional power plant.

In a general analysis of the economics of chemical processing, only the fissionable material of the power-producing reactor need be specified; it is not necessary to consider exact design of the reactor, flux, or power level. However, it is simpler to work with a specific reactor type and, since a breeder-type reactor gives the most complete utilization of fissionable and source material, a breeder is used as a basis for the following analysis. This reactor may operate on the uranium-plutonium cycle or the U^{233}-thorium cycle; the system determines the physical and nuclear constants to be used. Likewise, the general analysis will apply to both fast and thermal reactors, the difference again being the nuclear constants to be used. Therefore, while a thermal breeder reactor operating on the U^{238}-plutonium cycle is used as an illustration, it is with the understanding that the method will apply generally with the correct constants.

The breeder system that this analysis is based upon is illustrated in Fig. 1. The reactor contains U^{238}, Pu^{239}, and moderator. Inside the reactor, fission of plutonium takes place, producing heat, more plutonium, and fission products. Uranium, pluton-

ium, and fission products are withdrawn from the reactor continuously for processing; the fission products are separated out for disposal; and the uranium and plutonium are returned to the reactor for reuse.

The factors in this system that depend on chemical processing are (i) the number of neutrons absorbed by fission products inside the reactor that are removable by chemical processing; (ii) losses of fissionable material and source material during chemical separation and other processing outside the reactor, such as metallurgy or refabrication of fuel elements—that is, the losses in the external system; (iii) cost of chemical processing, metallurgy, refabrication, and handling external to the reactor. These three factors can be expressed in terms of cost per unit of electric energy produced and, by the use of simplifying assumptions, can be expressed as a function of the value of fissionable material, cost of processing, and losses.

The rate at which fission products build up in a reactor is $2N_f\sigma_f\phi$, where N_f is the amount of fissionable material in the reactor, σ_f is the fission cross section, and ϕ the neutron flux. If the equilibrium case is considered—that is, the case in which the reactor has reached steady state—the total amount of fission products in the reactor is given by $2N_f\sigma_f\phi T$ (*3*), where T is the process period. This assumes continuous withdrawal, processing, and return of the reactor fuel, in which case the process period, or chemical cycle, is the period of time required to process one complete reactor charge.

The rate of neutron loss to the fission products can be expressed as $2N_f\sigma_f\phi^2T\bar{\sigma}_c$ neutrons per day,

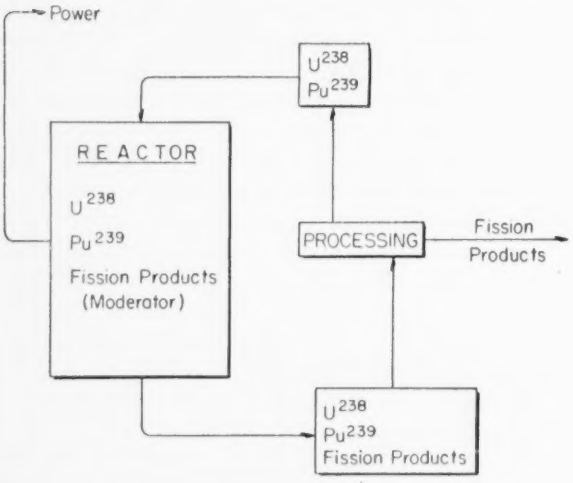

Fig. 1. The thermal breeder system consists of the reactor, facilities for converting heat to electric energy, and the processing facilities necessary to remove fission products from the fuel and to return unused fuel to the reactor.

where $\bar{\sigma}_c$ is the average neutron cross section of the fission products. Actually, the interest is only in the fission products removable by chemical processing, which excludes the high capture cross-section rare gases and rare earths, since they are removed from the reactor primarily by neutron capture or decay and are not significantly changed by the chemical processing considered here. Therefore, for this analysis $\bar{\sigma}_c$ is defined to exclude the high capture cross-section rare gases and rare earths, and an average for $\bar{\sigma}_c$ of about 25 barns (25×10^{-24} cm^2) seems to be reasonable, based on published cross-sectional and yield data. (*4*).

If neutron losses in the reactor are very low, as they must be for a successful breeder, a neutron absorbed by a fission product is almost equivalent to an atom of fissionable material lost. Based on this assumption, the rate of loss of potential fissionable material due to fission products in the reactor is $2N_f\sigma_f\phi^2T\bar{\sigma}_c$ atoms per day. If we further designate V as the value of the fissionable material (*5*) in dollars per gram, and P the electric output power of the system in kilowatt hours per day, then the value of neutrons lost to fission products in the reactor expressed as mills per kilowatt hour of electric energy is

$$\frac{2000N_f\sigma_f\phi^2T\bar{\sigma}_cVM}{AP} \text{ mills/kw hr,}$$

where M is the mass number and A is the Avogadro number. Since

$$P = \frac{N_f\sigma_f\phi(0.25)}{3.38 \times 10^{13} \times 3600} \text{ kw hr/day (based on 185 Mev per fission)}$$

assuming a 25-percent conversion of heat to electric energy, then the value of the neutrons lost as a function of the chemical process period is

$$4.05 \times 10^{-28}VM\phi T. \quad (1)$$

Next, if the losses of fissionable material in the chemical processing and other operations external to the reactor are considered, this loss is

$$VLN_fM/AT \text{ dol/day, or}$$

$$\frac{1000VLN_fM}{N_f\sigma_f\phi T(0.25)A} \times 1.22 \times 10^{17} \text{ mills/kw hr,}$$

where L is the fraction of material processed that is lost during processing. This then is equal to

$$\frac{8.1 \times 10^{-4}VML}{\sigma_f\phi T} \text{ mills/kw hr.} \quad (2)$$

The cost of processing may be expressed as

$$CN_fM/AT \text{ dol/day or}$$

$$\frac{1000CN_fM}{AN_f\sigma_f\phi T(0.25)} \times 1.22 \times 10^{17} \text{ mills/kw hr,}$$

where C (*6*) is the unit cost of processing in dollars per gram of fissionable material. (The value of C

must include the cost of all processing of fuel and source material outside the reactor. This, of course, includes returning the fuel and source material to a form suitable for reuse in the reactor.) This then becomes

$$\frac{8.1 \times 10^{-4} CM}{\sigma_f \phi T}. \qquad (3)$$

The sum of Eqs. 1, 2, and 3 is the total cost that varies with the chemical processing period, and may be written

$$\text{Total cost (mills/kw hr)} = 4.05 \times 10^{-26} VM\phi T + \frac{8.1 \times 10^{-4} VLM}{\sigma_f \phi T} + \frac{8.1 \times 10^{-4} CM}{\sigma_f \phi T}.$$

If plutonium is used as the fissionable material and the published fission cross section (*7*) for Pu^{239} is inserted, this becomes

$$\text{Total cost} = 9.7 \times 10^{-24} V\phi T + \frac{2.9 \times 10^{20}}{\phi T} (VL + C) \text{ mills/kw hr.} \qquad (4)$$

The chemical cycle that minimizes this cost, or optimum chemical cycle, may be obtained from Eq. 4, and

$$T_{opt.} = \frac{5.5 \times 10^{21}}{\phi} \sqrt{(VL + C)/V} \text{ days.}$$

This may be rewritten as

$$\sigma T_{opt.} = 5.5 \times 10^{21} \sqrt{(VL + C)/V}. \qquad (5)$$

Equation 5 establishes the flux-time that optimizes the variables which depend on the chemical processing. More specifically, this expression gives the optimum chemical cycle as a function of flux and the three parameters *V*, *L*, and *C*: the value of the fissionable material, the fraction lost in processing, and the unit cost of processing, respectively.

This expression for $\phi T_{opt.}$ leads to two useful conclusions: (i) At optimum ϕT the total cost of processing (the value of the material lost in processing plus the cost of processing) is given by

$$\text{Total cost of processing} = 0.053 V \sqrt{L + (C/V)} \text{ mills/kw hr.} \qquad (6)$$

(ii) The reactor poison-fraction, which may be defined as

$$\text{Poison-fraction} = \frac{\Sigma_c \text{ (fission products)}}{\Sigma_a \text{ (fissionable material)}} = 2N_f \sigma_f \sigma_c \phi T / N_f \sigma_a,$$

at the optimum chemical cycle (*8*) becomes

$$\text{Poison-fraction} = 0.175 \sqrt{L + (C/V)}. \qquad (7)$$

[This definition of the poison-fraction does not include the high-capture cross-section rare earths and rare gases, since $\overline{\sigma_c}$ is defined to exclude these fission products. It is not possible to include the poisoning due to fission products with high capture cross section and short half-life such as Xe^{135} in this general analysis since, even though it would appear in Eq. 7 as a constant for a given reactor, this type of poisoning is not independent of neutron flux. As an example, the constant that must be added to Eq. 7 for a reactor burning U^{235} at a thermal neutron flux of 1×10^{12} n/cm² sec would be 0.02 (*9*) to correct for the neutrons adsorbed by Xe^{135} and the high capture cross-section rare earths.]

Equation 7 then expresses the fraction of neutrons lost to fission-product poisons other than the very high capture cross-section fission products. The contribution of these elements to reactor poison is a constant for a given reactor and may be added to Eq. 7 to obtain an accurate value for reactor poison.

By the use of Eqs. 6 and 7, it is possible to evaluate the effect of the three parameters *V*, *L*, and *C* on the economics of a reactor designed for power production. If we say that the value of fissionable material as fuel will be approximately that of the equivalent amount of coal, with which it must compete as a fuel, the value of fissionable material is about 25 dol/g (*10*), based on a price of 8 dollars per short ton for coal. Using $V = 25$ dol/g in Eqs. 6 and 7:

$$\text{Total cost of processing} = 1.32 \sqrt{L + C/25} \text{ mills/kw hr,}$$

and

$$\text{Poison-fraction} = 0.175 \sqrt{L + C/25}.$$

This leads to the immediate conclusion that losses during processing which are less than one-fifth of the ratio C/V contribute less than 10 percent to the total cost of processing or optimum poison-fraction. This can be illustrated by using the earlier statement that a loss of less than 0.01 is necessary for economy. This is true only if C/V is much less than 0.05. If V is 25 dol/g, then C must be less than 1.25 dol/g of fissionable material for a loss of 0.01 to contribute 10 percent to the over-all picture. Next, let us pick a practical range for *C*, the unit cost of processing and, using 25 dol/g as a value for fissionable material, determine the significance of *C*. It is improbable that processing would be carried out if the unit cost of processing exceeded the value of fissionable material; therefore 25 dol/g represents a reasonable upper limit for *C*. As a lower limit, there is little need to consider costs of processing that do not contribute a significant amount to the cost of power. Table 1 gives the total cost of processing and the poison-fractions for values of *C* from 25 dol/g down to 20 ct/g as obtained from Eqs. 6 and 7.

It can be seen from Table 1 that consideration of unit costs of processing much below 1 dol/g of fissionable material is trivial with the assumptions

Table 1. Cost of processing and poison-fraction for $V = 25$ dol/g, $L = 0.01$.

Unit cost of processing (dol/g)	Total cost of processing (mills/kw hr)	Poison-fraction (%)
25	1.3	17.5
5	0.6	8.0
1	.3	3.9
0.2	.2	2.3

made, since little improvement can be made in the total cost of processing or the losses to removable fission-product poisons by lowering the cost of processing below 1 dol/g, and we have already concluded that a loss during processing of 0.01, or 1 percent, is reasonable at this cost of processing.

At 5 dol/g the cost of processing is 0.6 mill/kw hr. This total cost of processing represents about 10 percent of the cost of power from a present coal-fired plant and may be judged reasonable on this basis. However, at a cost of 25 dol/g for processing, both the poison-fraction and total cost of processing are obviously out of line.

This analysis then leads to the following conclusions concerning the processing of a power-producing thermal breeder reactor: (i) A loss of up to 1 percent of the material during processing is reasonable, and efforts to lower losses below this value at the expense of additional cost of processing are unreasonable. (ii) A unit cost of processing of the order of 5 dol/g is acceptable; however, 1 dol/g should be the goal of processing development.

These conclusions assume that the breeder system produces at least as much fissionable material as it consumes. If this is not true, then the value of fissionable material may no longer be based on its worth as fuel but rather depends on its market value. In this case V may be much higher than 25 dol/g. To illustrate how this would change the conclusions just drawn, $V = 50$ dol/g was used to construct Table 2, which is otherwise on the same basis as Table 1.

Table 2. Cost of processing and poison-fraction for $V = 50$ dol/g, $L = 0.01$.

Unit cost of processing (dol/g)	Total Cost of processing (mills/kw hr)	Poison-fraction (%)
25	1.9	12.5
5	0.9	5.8
1	.5	3.0
0.2	.3	2.1

An increase in V has the effect of lowering the optimum poison-fraction and increasing the total cost of processing for a given unit. This increase in V also reduces by one-half the amount of material lost during processing that is significant. From this it may be concluded that the requirements of chemical processing depend heavily on the performance of a breeder reactor; that is, if breeders do not make appreciably more fissionable material than they consume, even a unit cost of processing of 5 dol/g appears to be excessive on the basis that reprocessing cost not exceed 10 percent of the present cost of power.

References and Notes

1. David Lilienthal, "Atomic energy and American industry," speech before the Economic Club of Detroit, Oct. 6, 1947, AEC press release, p. 17.
2. F. R. Bruce, "Chemical development of radiochemical processes," Oak Ridge National Laboratory, Central Files No. 52–10–99, p. 6.
3. At equilibrium the amount of fission products in the reactor satisfies the differential equation $dN_{fp}/dt = 2N_f\sigma_f\phi - (N_{fp}/T) = 0$; therefore, $N_{fp} = 2N_f\sigma_f\phi T$.
4. Cross-sectional data taken from National Bureau of Standards Circ. 499 and Supp. 1, 2, and 3. Fission-product-yield data from Coryell and Sugarman, *Radiochemical Studies: The Fission Products*, "National Nuclear Energy" Ser. IV-9 (McGraw-Hill, New York, 1951).
5. The value of fissionable material as used here refers only to its value as fuel in a power-producing reactor.
6. Some justification is necessary for assuming C to be independent of the amount of material processed. This assumption is certainly not true for one reactor, but, since this analysis is considering the equilibrium case, a large system of reactors is assumed, and C for a given reactor of the system is probably independent of the amount of material processed.
7. $\sigma_f(Pu^{239}) = 664$ barns.
8. $\sigma_a(Pu^{239}) = 1025$ barns (total absorption cross section).
9. Based on a capture cross section of 3.5×10^6 barns for Xe^{135}, a half-life of 9.2 hr, and a yield of 5.6 for mass 135—a high cross section for rare earths with a yield of 1.6 percent.
10. Since 1 lb of fissionable material is approximately equivalent to 1250 tons of bituminous coal, at 8 dol/ton this turns out to be 22.50 dol/g of fissionable material.

Since there are no—or only a very few—ideal people who are entirely free from prejudice, it is sometimes of value to obtain information, especially in regard to historical data, from two different points of view.—WILHELM K. ROENTGEN.

SCIENCE ON THE MARCH

Spotting Forest Fires with Television

THE hottest thing about a forest fire at the moment seems to be the latest experiment in Louisiana on spotting blazes by television. State Forester James E. Mixon, who witnessed the first test recently with the Louisiana Forestry Commission board, reports "very promising results."

The outdoor television apparatus was assembled by Bill Maeser and Carl LeBlanc, of the Louisiana Radio & Television Distributors of Baton Rouge, and Al Vendt, Communications Engineer of the Louisiana Forestry Commission. They have tagged their assembly with the name "detecto-vision."*

The system works with industrial-type television cameras in a Plexiglas dome mounted on top of a forest fire tower. The camera is rotated continuously by means of a ratiomotor geared to a speed of less than ½ rev/min. In other words, the camera eye scans the treetops exactly as a towerman does but in a more deliberate manner. It also sees more, because it is equipped with a telephoto lens and can pick up a cow munching grass 4 mi away, as was demonstrated during the test.

Azimuth markings are located on the dome, so the camera picks up the degree readings at the same time that it scans the landscape. Because the camera's lens cannot pick up the degree readings unblurred, there is a special bifocal lens included in the equipment to read the close-up numbers on the dome. The bifocal lens, however, is brought into focus only after the fire is spotted. Numbers appearing on the camera screen hamper vision slightly, so the technician simply flips a switch, and the bifocal lens is deactivated while the camera is scanning the scenery. When a fire is spotted, the technician stops the camera by remote control, flips the bifocal lens on, and takes his reading.

Instead of a cable, microwave equipment supplied by the Raytheon Manufacturing Company transmitted the images to a television set 50 mi away at the Alexandria State Forest near Alexandria. Forest fires were spotted as far as 20 mi from the camera tower.

If "detecto-vision" becomes an accepted practice throughout a parish or the state, technicians explained, there would be about three to five cameras operating in a parish. A television set for each camera in a parish would be located in a central control station where one operator would watch all sets of fires. By reading the azimuth bearing on a fire off two sets, he could immediately get a "cross-out" between the two and locate the exact

Fig. 1. Plexiglas dome and microwave equipment atop a forest fire tower.

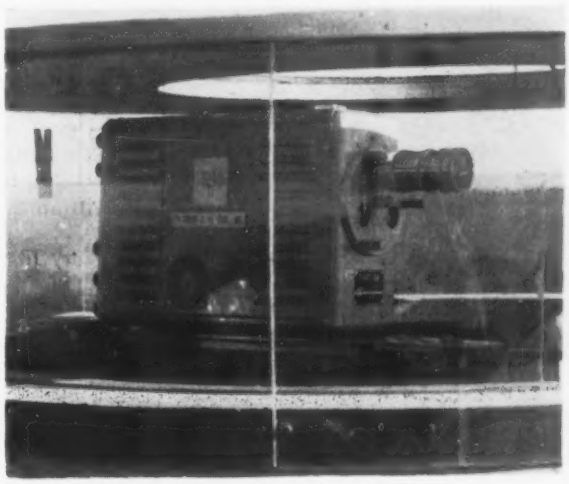

Fig. 2. Television camera inside the Plexiglas dome.

* Patent pending.

position of the fire, much the same as is done now by towermen.

State Forester Mixon sees possibilities for use of the system even in the very near future, "because it could well be used to give towermen, who are on call 24 hr a day, some rest from tower duties."

The state forester also reported that tests have been made to spot arsonists in the woods and s "many woods burners would be uneasy right n if they knew how well we can focus a clear pict on a man miles away."

Ed. Ke

Louisiana Forestry Commission, Baton Rouge

Technical Writing and Editing

Excerpts from articles that appeared in the Annual Book Issue of Science *23 Apr. 1954.*

From a close examination of the writing in many scientific publications (including, if you do not mind, *The Scientific Monthly*), one would never guess that as a nation we are renowned for efficiency. Sentences bulge like overfed matrons with unnecessary words that obscure a writer's ideas and weaken his emphasis, much as the matronly fat obscures the streamlined glory of the past. For both matrons and sentences, a major solution is diet: for writing, a diet of efficient verbs. . . .

Science writers' fascination for the passive is deplorable but understandable. For describing experiments, the passive (without the doer) sometimes performs even more efficiently than the active. Too, editorial demand for objectivity may force a writer into abandoning "I," which eventually leads him to "the writer," which eventually generates self-consciousness, which finally sends him slinking to the passive. Thus, editorial policy and the passive's efficiency in specific circumstances may develop in the writer a passive-psychosis, a state in which the patient cannot differentiate between a good passive and a bad one. However faulty this diagnosis, something certainly causes the disease, and to cure it a writer might well consider every passive sick until he proves it healthy.—Herman R. Struck, "Recommended diet for padded writing," pp. 522, 525.

Editors of scientific writing, whether technical reports, research papers, books, or popular articles, have obligations to both author and reader. For the sake of the reader, the editor must help the author to say what he means in the simplest way; to eschew jargon when it is merely high sounding, for then it is bad jargon; to use technical terms in technical writing when they lead to clearness and conciseness, for this is good jargon; to recognize the advantages of acquiring "the habit of paying all words the compliment of respecting their peculiarities." Good writing comes hard, but the gain is worth the labor. There is sound advice in the words of Isaac Watts:

> Smooth be your style, and plain and natural,
> To strike the sons of Wapping or Whitehall.
> While others think this easy to attain,
> Let them but try, and with their utmost pain
> They'll sweat and strive to imitate in vain.

—Joseph D. Elder, "Jargon—good and bad," p. 538.

I am told that hell hath no fury like a dues-paying professional society member grown scornful of his society's publication.—Ralph B. Smith, "Publishing as applied science," p. 538.

BOOK REVIEWS

Arctic Bibliography, vols. 1, 2, 3. Prepared for and in cooperation with the Department of Defense, under the direction of The Arctic Institute of North America. Supt. of Documents, Washington, D.C., 1953. 1478 pp. + maps. $12.75, set of three volumes.

PRESENT-DAY interest in the higher latitudes has created a demand for knowledge of scientific literature in many fields and covering wide territory. Newcomers, and even some old hands, often waste time searching for source material, and reference librarians rarely accustomed to working in this highly specialized realm find themselves at a loss to know how to begin. Through the foresight of the Arctic Institute of North America and the intelligent cooperation of the Department of Defense, every student of the Far North can now secure, in compact form, a dependable "starting place" in his search of northern literature.

Arctic Bibliography, despite its formidable appearance, is essentially a simple biliographic tool. References, to the number of 20,003, are listed by author. They are arranged in two volumes, beginning with an item by "A., A." on the timber industry of Igarka, USSR, and concluding with one by "Zykov, V." who deals with the Crustacea of Kolguyev Island, also in the USSR. The third volume serves as index to the other two. In it, entries are listed by subject and area. The area classification is shown on a large folded map, with the 69 regional sections overprinted in red, along with a list of their names. The first reference mentioned earlier in this paragraph can be found in the index volume under "Igarka (region)," where the inquirer is referred to item 1 in vol. 1.

The bibliographic entries were culled from a comprehensive group of about 1500 journals, the titles of which are listed in vol. 1. Wherever possible, the article has been examined and the library holding it has been stated. Each bibliographic entry consists of the title transcribed from the publication itself and a bibliographic description of the item in standard library style, including citation of journals and other serials as they are listed in "Union List of Serials in Libraries of the United States and Canada." An annotation or analysis descriptive of the publication's matter is added.

The convenience and comprehensiveness of *Arctic Bibliography* can best be illustrated by selecting a few examples. It may be appropriate to use the name of Henry Collins, who headed the directing committee of the project, as the first. Item 3325 on p. 518 of vol. 1 begins "Collins, Henry Bascom, 1899–, and others. The Aleutian Islands: their people and natural history . . . ," and so on. There follow 27 additional entries by the same author, the last being on p. 521. Entries have, of course, been selected without restriction of national origin or language, so that under "Shmidt, Otto Jul'evich, 1891—," the authority on Arctic USSR, are found 18 references, and under the name "Rink, Hinrich Johannes, 1819–1893," the Danish scientist and administrator, are 50 items published in Danish, English, German, or French.

Approach by way of the index is equally facile. Under "Marine fauna," for example, one is cautioned to look also under "Plankton, names of phyla. . . ." There follow entries under the many regional headings already described, as well as general entries, and several bibliographies.

Specialists searching for recent items in their own fields may not be rewarded, although I have had several pleasant surprises. The present volumes include the results of a systematic search through the 1949 issues of journals. It is hoped that subsequent entries will appear in supplementary volumes.

The Arctic Institute has served science well in initiating this formidable undertaking, in seeing it through when faced with discouragement, and in enlisting the support of the Department of Defense. Special praise is due to the Office of Naval Research, with whose aid the project was started in 1947. In time *Arctic Bibliography* will prove itself to be all but indispensable to northern research workers. Its value as a training aid for undergraduates cannot be overestimated.

A happy combinaiton of private initiative and government support has enabled the *Bibliography* to appear at very reasonable cost. It is to be hoped that the project so successfully begun can be continued as a permanent undertaking.

TREVOR LLOYD
Department of Geography, Dartmouth College

Jaarboek, 1952–1953. Koninklijke Nederlandse Akademie van Wetenschappen. Noord-Hollandsche Uitgevers, Amsterdam, 1953. 347 pp. Illus. + plates.

A YEARBOOK of a learned society by its very nature is mainly concerned with providing the reader with an account of its activities, a list of its members, a list of its various funds, an account of the way these funds have been administered, and so on. This volume is no exception and fulfills its task admirably. For the American reader, a two-page English summary is added at the end of the book, giving a brief résumé of the present situation of the Royal Netherlands Academy of Science.

In 1808, during the French occupation of the Netherlands, King Louis Napoleon founded a Royal Institute of Sciences and Arts, built along the lines of the French Académie. This Royal Institute lasted until 1851 when a Royal Academy of Science was founded with the purpose of fostering mathematical sciences. In 1855, however, the scope of this academy was enlarged to encompass also arts, and the Royal Netherlands Academy of Science has been in its present form since then.

Among its activities are advising the Dutch Government (to a steadily increasing degree), managing its many funds (among which is the Lorentz fund out of which the Lorentz medal is awarded every fourth year, an award second only to the Nobel Prize in physics; its recipients have been Planck, 1927, Pauli, 1931, Debye, 1935, Sommerfeld, 1939, Kramers, 1947, and F. London, 1953), the election of a Ramsay Memorial Fellow to study chemistry in England, the encouragement of radioastronomy and of the study of Dutch dialects. In this yearbook, one can find how far the Academy has fulfilled its duties in all these respects.

The yearbook contains the text of an open lecture by J. M. Burgers on "The frontier sciences of hydro- and aerodynamics" and obituaries of J. v. d. Hoeve, H. A. Kramers, G. Krediet, S. N. Winogradsky, J. Jud, W. E. J. Kuiper, and M. I. Rostovtzeff.

D. ter Haar
St Salvator's College, St Andrews, Scotland

The Living Brain. W. Grey Walter. Norton, New York, 1953. 311 pp. Illus. + plates. $3.95.

This excellent book, although intended for general reading, is a successful attempt to present the scientific significance of electroencephalography. Rather than develop the clinical side, the author emphasizes the background philosophy and probable future use of recorded brain potentials in the study of brain function. Along with his great experience as a pioneer in the science and techniques of this field, he has the happy faculty of writing with clarity, literary brilliance, and humor.

From the absorbing first chapter, "Lords of the earth," dealing with the evolution of the brain, the exposition marches on through the early history of electrophysiology, the discovery by Caton in 1875 that the brain itself produces electric currents, and the significance of Pavlov's experiments to Adrian and Matthews' confirmation that Hans Berger's "wobbly line" was indeed a recording of electric energy derived from the brain.

The description of the variations of the EEG is linked with the significance of pattern in relation to sensory stimulation. The use of the Walter wave analyzer in displaying the various electrical components and the variations induced by imposing sensory patterns on the brain is discussed in "Revelation by flicker." In the chapter on "Totems, toys, and tools," a stimulating and thought-provoking description is given of the author's electromechanical creatures: Machina speculatrix and M. docilis; imitations of reflex circuits and delightful teaching toys for grown-up "laboratory children."

In the chapter "Learning about learning," the convergence of two major fields of investigation is discussed: the later theory of Pavlov on the difference in types of response to conditioning, and the electrical phenomena of the brain. Some interesting meanings of the electrical pattern are cited: visual imagination and alpha rhythms are mutually exclusive; theta activity begins when a pleasant sensation ends; fast activity is prominent during mental tension and anxiety states and alpha activity represents a process of hunting for information—that is, a kind of scanning process.

In later chapters, Shipton's toposcope and the mechanical models and the frequency analyzer, invented by Walter and his colleagues, are described in relation to their use in investigating the physiology of learning. The problems of constructing a learning box and having it retain a "memory" carry the reader into the difficulties of mechanized reflex activity.

In the long chapter entitled "Intimations of personality," those interested in the correlates of the EEG rhythms with various personality traits will have a rich reward. "The brain tomorrow" chapter summarizes the main concepts of the book and attempts to analyze the possible future use of the growing data and improving techniques of the physiologist in the study of the "organ of mentality." Here, as elsewhere in the book, there is some slight danger that the reader may become stalled in the midst of a beautiful analogy. As many questions are asked by the author as he answers, but they are stimulating fun for the reader and should increase, at least temporarily, his "beta" activity.

In the extensive appendix, an electric model of nerve, the design of M. speculatrix, and a conditioned reflex analog are analyzed and diagramed. This well-written book should be read for its facts and for its "excitation" value by all who are interested in brain function. The brain has taken a good look at itself.

Robert H. Oster
Department of Physiology, School of Dentistry
University of Maryland, Baltimore

General Virology. S. E. Luria. Wiley, New York; Chapman & Hall, London, 1953. xiii + 427 pp. Illus. $8.50.

During the past three decades virology has developed into a branch of biological science comparable in importance to bacteriology itself. Having "come of age," it is fitting that it should begin to be regarded as an independent science. *General Virology*, by Luria, represents an attempt to present virology as an independent biological science and its relationship with animal and plant pathology, bacteriology, and various branches of chemistry. He points out that the development of the science has occurred, not in a straight path, but rather through the slow accumulation of empirical knowledge. Since the accumulation of virus information and literature has attained enormous proportions, Luria concludes that virology has reached the stage when some attempt at integration of knowledge is justifiable. It is for this reason that the author stresses generalizations rather than exceptions and throughout the text associates the study of viruses with the study of intracellular elements and cellular organization. The physical and chemical properties of virus particles and the physiological aspects of the virus-infected cell are treated as separate but integrated parts of the same study. Together with a liberal use of well-

chosen references, the author presents background information of an elementary nature in simple and concise terms.

The theme of the book is based around the concept of the dual nature of viruses, as inert particles on the one hand and as integral operating constituents of the living cell on the other. The study of this relationship is considered an important phase of the science and the double idea is mentioned throughout consideration of the various aspects of this subject.

Descriptions of virus diseases have been omitted, with facts concerning individual viruses being presented as model systems or examples. The purpose behind this approach is to point out important methods, new ideas, and articles that lead to further references, rather than to detail individual peculiarities. The author presents several technics which may be used in determining the potency of virus preparations. It is unfortunate that no attempt is made to evaluate the reliability of the various procedures.

The book is a basic textbook in a comparatively new field. It will be of use to both the student in elementary virology and to the graduate student in microbiology and related sciences. For the type of person who is interested in the wide range and academic level of articles which appear in *The Scientific Monthly* such a book would be an excellent addition to the library. It is an erudite yet simple and readable presentation of the scope of the science of virology and it answers a real need for the integration of fundamental knowledge in this field.

S. Edward Sulkin

Southwestern Medical School of
The University of Texas

Advances in Virus Research. Vol. I. Kenneth M. Smith and Max A. Lauffer, Eds. Academic Press, New York, 1953. 362 pp. Illus. $8.

This new periodical review of progress in virus research will be welcomed, not only by the hundreds of persons who actively investigate the viruses of animals, bacteria, and higher plants, but also by the much larger group of onlookers to whom virology is a branch of the biological, medical, and agricultural sciences that is developing at such a remarkable pace that any summary of its present state is likely to be outdated before it can leave the press. Critical reviews of progress in virology are particularly needed because its literature is so widely scattered in the journals of medicine, veterinary science, entomology, plant pathology, chemistry, biochemistry, bacteriology, and genetics that it is out of the question for any one individual to keep up with all of it.

Volume I of the new series begins with Herman T. Epstein's summary of the state of bacterial virology. Bacterial viruses and their hosts offer many advantages from an experimental standpoint. The opportunities they offer have been so well used that bacterial viruses, particularly the so-called T phages of *Escherichia coli,* are in many respects the best understood of all viruses. So much is known of the details of their life-cycles—their structures, their adsorption by host cells, the entrance of desoxyribonucleic acid genetic material into the host, the multiplication of genetic material, genetic recombinations, mutation, formation of protein coats, assembly of viral progeny, and the final lysis of host cells—that they are increasingly used as a basis of comparison for other viruses

C. W. Bennett brings together the facts known about interactions between different viruses of higher plant species. A given plant may be at one time host to several serologically unrelated viruses. In general, however, viruses closely related serologically will not multiply within a single plant.

Many higher plant viruses are transmitted by aphids, leafhoppers, or other sucking insects. L. M. Black describes the ways in which leafhoppers serve as virus vectors. In many instances only a few, sometimes only one, of the hundreds of species of leafhoppers carry a given virus. In one species the state of a single gene determines whether or not the leafhopper will transmit the virus. In some cases the virus multiplies in the insect vector; in others it appears not to. But in no case is the virus known to produce detectable disease symptoms in the insect itself.

Another group of viruses, limited to insects, includes the polyhedral and capsule diseases. These are reviewed by G. H. Bergold. Only recently has it been discovered that the remarkable polyhedral inclusion bodies are made up of noninfectious proteins in which are encased bundles of infective virus units made up of protein and nucleic acid. These viruses may in some instances be transmitted through the eggs of the host.

In reading Werner Henle's account of what is known of the life-cycle of influenza virus as introduced into the allantois of the chick embryo, it is not difficult to see the influence of the methods and findings of bacterial virology. There are many parallels, including evidence of genetic recombination not unlike that of the bacterial viruses.

With the coming large-scale tests of Salk poliomyelitis vaccine on children, Joseph L. Melnick's chapter on the viruses of poliomyelitis is both timely and informative to the nonspecialist. The recently developed methods of growing these viruses on a large scale in tissue culture are described, as are the properties of the viruses themselves.

In contrast to at least some of the plant viruses, the isolation of higher animal viruses in pure form is often a discouragingly long and tedious process. The methods used and the properties of the isolated viruses as determined by physical methods, serological techniques, and electron microscopy are reviewed and evaluated by D. Gordon Sharp.

In a concluding section, Roy Markham summarizes recent work on virus nucleic acids. There has been a great upsurge of interest in these substances, both because of new methods of study, and because several lines of evidence indicate that they make up the genetic material of viruses, bacteria, and presumably all other

organisms. Just about the time the volume under review came off the press, the Watson-Crick structure of desoxyribonucleic acid was reported. Presumably Volume II, of *Advances in Virus Research* will explain how and why this structure is thought to be of such great significance in virus and gene duplication, in mutation, and in protein synthesis.

Every virologist will want to have access to *Advances in Virus Research* and will look forward to future volumes. The same is true for others who want to keep up with the rapid developments in this field that is of such obvious importance to both basic and applied branches of the biological sciences.

G. W. Beadle
Division of Biology, California Institute of Technology

Mitosis. The movement of chromosomes in cell division. ed. 2. Franz Schrader. Columbia Univ. Press, New York, 1953. xii + 170 pp. $4.

The second edition of this monograph has about 50 percent more pages than the first edition of 1944. However, a substantial part of this enlargement is due to the adoption of a larger type; hence there are fewer words on each page. The method is unchanged, and the narrow objective is the same—namely, to deal with the mitotic spindle and the kinetochore (that is, centromere) by which the chromosome is attached to this body. The method is to discuss theories—ancient and modern. Observations and experiments are used to test these but not in any inductive manner to arrive at some generalization that may be useful. In turn, it appears that each of the hypotheses that have been broached has in it no promise of a final solution.

It is a depressing, confusing, disheartening story, tempered only by the expressed hope that still further concentration in the attack and its limitation to a single phase of the mitotic cycle may yet yield "definite promise of a final solution." The trouble is to choose the limited phase, which almost implies prior knowledge of the critical point in the solution. That attack on the spindle mechanism itself has apparently failed is indicated by the lack of advance from Schrader's analysis of nearly a decade ago and suggests that this is not the vulnerable point. Indeed, all scientific advances are made by probing on a broad front, with all the weapons at command, and then attacking strongly wherever penetration may be achieved.

Schrader has discussed the evidence from a number of methods of study excluded from the previous discussion. It appears that our information on the chemistry of cell constituents is too restricted for purposes of mitotic analysis. Experimental analysis, by the acceleration or retardation of cell division, has produced a mass of work in which "it seems hopeless to recognize a common denominator." Agencies, like colchicine, which affect only certain cell structures or activities "would offer a better opportunity," but unfortunately "colchicine also exerts an influence on the chromosomes . . . and the cytoplasm . . . ." The fact is that the cell is a delicately balanced and integrated system, and any disruption in one of its parts or functions is bound to have other and far-reaching effects. Surely these pleiotropic effects should give some clues to the mechanism and its integration. Indeed they force Schrader to concede that the "chromosomes themselves play an active part in the mitotic mechanism" and that mitosis comprises "a great complex of different mechanisms." But he has failed to piece together any of the clues.

No matter how urgently we need more information about the physical chemistry of the cell, it is certain that we have no more powerful tools as yet than a microscope and a keen mind. Schrader's book does a service in demonstrating that it will yet be possible for the open mind to piece together the fragments garnered by the microscopist.

D. G. Catcheside
Department of Genetics, University of Adelaide Adelaide, Australia

Paying for Medical Care in the United States. Oscar N. Serbein, Jr. Columbia Univ. Press, New York, 1953. xxiv + 543 pp. $7.

The practice of medicine and particularly the economic aspects of the practice of medicine have been subjected to many close scrutinies within the past fifty years. The latest of these is in the study "Paying for Medical Care in the United States" done by Oscar N. Serbein, Jr. under a grant from the Health Information Foundation to Columbia University. This study does not pretend to any original research or even collection of data but is based entirely on data already collected and is essentially a compilation. Nor does it draw any conclusions as to what method of payment is to be preferred. Neither does it make any suggestions as to any new methods which might be developed or invented. In this it differs from many of the studies made in recent years, and particularly from the report of the President's Commission on the Health Needs of the Nation upon which Professor Serbein's study draws in a number of places.

By following this line the study is able to maintain a strict objectivity. Furthermore the data, collected from other sources, is beautifully analyzed and nicely arranged. The plan of presentation is well organized and particular attention is paid to the deficiencies in our present information, pointing out the desirability of a statistical agency whose function is to remedy these deficiencies in our available information. All who have worked in this field have felt this acute need. The evaluation of the various sources of information for validity seems very sound.

The sections dealing with various forms of prepayment for medical and hospital bills are very well done indeed and include much information which has never been brought together in one place before. This situation is changing very rapidly, and the author recognized this and makes some suggestions as to direction likely to be taken in the future. The description of the

rious plans presently in operation is complete and nely. There is a good deal of actuarial data included ough to be sure this must be supplemented by anyone ho is actually going into the business of setting up a epayment plan. The Blue Shield and Blue Cross Plans re adequately described and evaluated.

The role of government in the provisions of health re is covered fully and without the slightest trace of as. It is quite impossible to determine whether Pro-sor Serbein is in favor of more or less government the health field. This is a refreshing experience. Most the recent studies have lost their objectivity in violent nunciation of "socialized medicine" or subservient pport of governmental programs. In this book is a ncise but quite complete survey of all governmental rticipation in the health bill.

Finally the many tables are of inestimable value to yone interested in this problem. There are 237 of em and they include the answers to most of the "how uch" and "how many" questions that can be asked. This is a careful study. It is a valuable addition to e growing mass of material accumulating on the costs medical care. It is essentially a good job of report-g. One might wish that Professor Serbein would take e material he has collected and comment upon it edi-rially. What should we do now, Professor?

RUSSEL V. LEE

lo Alto Clinic
lo Alto, California

hemical Methods in Industrial Hygiene. Frederick H. Goldman and Morris B. Jacobs. Interscience, New York, 1953. ix + 274 pp. Illus. $3.75.

THIS book is a laboratory manual that provides detailed methods available to the average chemist nd commonly used in the field of industrial hygiene. The authors state in their preface that the methods escribed are not necessarily official methods, but they ave nevertheless provided a convenient collection of he methods in common use for chemical analysis of amples taken for industrial hygiene purposes. Standard eferences now in use in analytic laboratories doing in-dustrial hygiene work exclusively are certainly more engthy than this manual, but with these more volumi-ous textbooks it is necessary to select the method with o knowledge of their accuracy or usability. *Chemical Methods in Industrial Hygiene* eliminates this searching or suitable methods; although, as the authors state, it does not exhaust all material or include such spe-ialized techniques as x-ray diffraction, polarography, spectroscopy, and petrology, the methods presented do "work" and are in wide usage.

A brief discussion is presented on sampling methods, but since this is not the prime intent of this manual it would be necessary for someone new to the field of industrial hygiene to look elsewhere for more complete data on sampling methods. Information is presented on preparation of the standard reagents used in industrial hygiene analysis. In addition to the very excellent selection of methods for both inorganic and organic compounds, a valuable bibliography is included to allow the student or chemist to investigate the methods more thoroughly if he so desires. An appendix, including threshold limit values for various materials, conversion tables, and a quick reference table of preferred methods of sampling, and analytic procedures is included. The volume is well indexed.

In general, this is a manual of analytic chemistry, but two chapters depart from the field of chemistry into the field of physical analysis. Chapter III presents the microscopic methods used for studies of dusts, and Chapter IV discusses both the chemical and certain petrographic methods used in the determination of free silica in dust.

Chemical Methods in Industrial Hygiene undoubtedly will prove to be a very popular laboratory and office aid for both the full-time practicing industrial hygienist and the chemist or chemical engineer who occasionally must do work in this field.

KARL L. DUNN
Corning Glass Works, Corning, New York

Educational Wastelands. Arthur E. Bestor. Univ. of Illinois Press, Urbana, 1953. 226 pp. $3.50.

BASED on dubious assumptions, *Educational Wastelands* attacks alleged current educational practices and attempts proposals for reconstruction. The assumptions include: (i) that what was good enough for the Jeffersonian aristocracy is good enough for everyone; (ii) that an education in the "academic disciplines" is necessary and sufficient for all children in current society; (iii) that schools should not modify their programs, despite the changing aspects of the school population or of the nervous world in which we live; and (iv) that "professional educationists" constitute an "interlocking directorate" so powerful and persuasive that 80,000 school boards (responsible for their local curriculums) and all the state legislatures vote educational laws and programs in blind obedience.

Under thoughtful and realistic appraisal, these assumptions do not survive. For a historian, Bestor seems astonishingly insensitive to changes in our culture during the past 50 years. While we might agree that many responsibilities *should* be taken by the home, the facts are that these are *not*. What then are the responsibilities of teachers and school folk who are devoting their lives to helping children mature? The sympathetic and constructive assistance of collegiate faculties is greatly needed. But this book is based on scant evidence—mainly assertions culled from the extremists, poisoned with "snarl words," and colored with purple passages. Ridicule hardly constitutes a constructive approach to the serious problems of education that are far more complex than this prejudiced treatment would imply.

To follow the author in applying to the existing school population narrow programs and criterions assumed adequate a century ago is to invite *real* educational chaos. During the past 70 years enrollments in

our secondary schools have risen some ninety-fold. Legally required attendance to the age of 16 has brought children of all sorts of interests and abilities to the schools supported by their parent's taxes. Bestor's brief comments on vocational training and on the slower-than-average child are but gestures of resignation toward a sizable portion of the actual children in actual schools. While most teachers have concern for the "liberal arts," what to do with this variety of children in the schools and how to do it are questions to which there are no easy answers.

Many of the teachers meeting these children came from the liberal arts colleges and would appreciate the realistic help of their former mentors. But the historical record plainly shows that early in the century when the complexities of schooling became increasingly apparent, most of the professors turned to scholarly research. Schoolmen were left to fend for themselves, to create and staff new institutions for the preparation of teachers, and to plan instruction for the hosts of students not college-bound. To castigate with sneers and innuendoes those who have struggled alone with an overwhelming volume and variety of educational problems smacks of a "guilt complex."

To be constructive, help must be based on realistic observation and thoughtful appraisal of the role of schools in our present society—not on a stereotype carried over from 1890. Enormous help is needed, but Bestor does not know how to begin.

FLETCHER G. WATSON
Graduate School of Education, Harvard University

Energy in the Future. Palmer C. Putnam. Van Nostrand, New York, 1953. x + 556 pp. Illus. + tables. $12.75.

IN 1949 the Atomic Energy Commission requested Palmer Putnam "to make a study of the maximum plausible world demands for energy over the next 50 to 100 years." This book is the resulting report. It is a big book, packed full of data. It is fascinatingly interesting. And it is important.

A little less than the first half of this book consists of eight chapters, plus summary and concluding remarks. The remainder consists of notes on the preceding chapters, with extensive references, tables of base data, and multitudinous supporting details. Of the eight chapters, the first is a very short general introduction which states the problems being attacked, the methods to be used, the assumptions made, and certain aspects which will be ignored. The next two chapters review the demographic facts for the entire planet and for all of recorded history, culminating in population forecasts for the United States and for the world in 1975, 2000, and 2050.

The fourth chapter analyzes the history, to date, of the sources and uses of energy in the United Sta the Union of Soviet Socialist Republics, the Un Kingdom, Germany, India, Japan, France, and Ar tina. On these data as a base, the next chapter estim the world's maximum plausible demands for energy the century from 1950 to 2050. The remaining chap consider how long we can "live high" off capital ene (fossil fuels) and off income energy (currently or cently received from the sun). The final main chap then considers the possible future role of nuclear fu

Early in his book the author sagely quotes Hila Belloc: ". . . men prophesy and the future makes fo of them." But Mr. Putnam was asked to prophesy, a it is surely the case that he has brought an enormo amount of data, a disciplined and reasonable mind, real capacity for exposition, and a most sensible ca tion to bear on the great questions he considers. If b book is read as carefully, reasonably, and cautiously it was written, it will be as valuable as it is interesti

WARREN WEAV
Rockefeller Foundation
New York City

Keeping and Breeding Aquarium Fishes. C. W. Emmens Academic Press, New York 1953. x + 202 pp. Illu $4.50.

THE tremendous increase in the keeping of tropic fishes, with its attendant rash of popular publica tions during the last decade or so, has caused the pro mulgation of a number of fallacies based on unassimi lated bits of scientific knowledge. This is to be expected since keeping fishes is an art that most of its practi tioners follow with more enthusiasm than light. Con sequently, a book written by anyone with more tha casual acquaintance with any of the biological science could be of great value. Emmens is such a person; hence his book is of some importance, even though he is an amateur in fish-keeping. At least he recognizes most o the fallacies and those he does not actively attack he at least skirts with a statement that not all is understood about this particular aspect and that one should tread warily.

While Emmens seems to have studied most of the fundamentals of fish-keeping, some of the details appear to have escaped his notice; occasionally he makes state ments that are at variance with the facts. Even so, the book is really an enormous improvement over the run of-the-mine tropical fish books, and it has a good deal of information that all fanciers could use with profit In fact, many of the sections could easily be used as supplements to textbooks in biological laboratory methods.

CHRISTOPHER W. COATES
New York Zoological Society, New York

LETTERS

Religious Motivations in Scholarly Pursuits

I was most interested by Leonard Carmichael's article, "Laziness and the scholarly life [*The Scientific Monthly* 78, 208 (1954)] but regret that the author did not adequately explore the effect of religious motivations on scholarly pursuits. Will not a great many scientists recognize a close connection between the basic desire to serve God and the search for the truths of His creation? In my own opinion, the "well-planned" life leads not only to intellectual achievement but also to the salvation of the soul.

JOSEPH L. O'BRIEN

720 Chestnut Street, Philadelphia 4, Pennsylvania

I agree that for many wise people religion provides a fundamental motivation for life. History supports the view that numerous human achievements in art and other fields have been related to the desire of the individuals who created them to attain salvation. No one, for example, can understand the cathedrals of medieval Europe without recognizing the power of this motivation.

LEONARD CARMICHAEL

Smithsonian Institution, Washington 25, D. C.

Crocodile Tears

Francis Bacon (1561–1626) too may be added to Clifford B. Moore's interesting list of "authorities" on crocodile tears [*Sci. Monthly* **78,** 228 (1954)]. In his essay "Of Wisdom for a Man's Self," Bacon wrote: "It is the wisdom of crocodiles, that shed tears when they would devour."

IRVING H. SIEGEL

The Twentieth Century Fund
Washington 5, D.C.

Books Reviewed in SCIENCE

June 4

Southern African Mammals, 1758 to 1951: A Reclassification, J. R. Ellerman, T. C. S. Morrison, and R. W. Hayman (British Museum). Reviewed by Charles O. Handley, Jr.

A Practical Manual of Medical and Biological Staining Techniques, Edward Gurr (Interscience). Reviewed by Ross G. MacCardle.

Chemical Physiology of Contraction in Body and Heart Muscle, A. Szent-Györgyi (Academic Press). Reviewed by L. J. Mullins.

Sample Survey Methods and Theory, vols. I and II, Morris H. Hansen, William N. Hurwitz, and William G. Madow (Wiley; Chapman & Hall). Reviewed by Samuel Weiss.

Elements of Statistics, H. C. Fryer (Wiley; Chapman & Hall). Reviewed by F. M. Wadley.

June 11

The Design of Social Research, Russell L. Ackoff (Univ. of Chicago Press). Reviewed by Harry Alpert.

Human Embryology, ed. 2, Bradley M. Patten (Blakiston). Reviewed by Carl L. Davis.

Radioisotope Techniques, vol. I, Medical and Physiological Applications (H.M. Stationery Office). Reviewed by H. D. Bruner.

Magnetic Cooling, C. G. B. Garrett (Harvard Univ. Press; Wiley). Reviewed by R. P. Hudson.

Hypnotism: An Objective Study in Suggestibility, André M. Weitzenhoffer (Wiley; Chapman & Hall). Reviewed by W. O. Ramsey.

June 18

Advances in Veterinary Science, vol. 1, C. A. Brandly and E. L. Jungherr, Eds. (Academic Press). Reviewed by I. Live.

Sex Determination, ed. 3, F. A. E. Crew (Methuen; Wiley). Reviewed by J. A. Weir.

The Physiology of Man, L. L. Langley and E. Cheraskin (McGraw-Hill). Reviewed by Joseph T. Velardo.

Silicified Middle Ordovician Trilobites, H. B. Whittington and W. R. Evitt, II (Geological Society of America). Reviewed by Franco Rasetti.

Recent Progress in Hormone Research, vol. VIII, Gregory Pincus, Ed. (Academic Press). Reviewed by Dietrich C. Smith.

Probability and Information Theory, with Applications to Radar, P. M. Woodward (McGraw-Hill; Pergamon Press). Reviewed by Jerome Rothstein.

June 25

Projective Geometry and Projective Metrics, Herbert Busemann and Paul J. Kelly (Academic Press). Reviewed by M. S. Knebelman.

Robert Grosseteste and the Origins of Experimental Science, 1100–1700, A. C. Crombie (Oxford Univ. Press). Reviewed by Duane H. D. Roller.

The Challenge of Man's Future, Harrison Brown (Viking Press). Reviewed by Leonard Carmichael.

Dielectric Aerials, D. G. Kiely (Methuen; Wiley). Reviewed by Paul H. Nelson.

Solubilities of Inorganic and Organic Compounds: A Compilation of Solubility Data from the Periodical Literature, supplement to ed. 3, Atherton Seidell and William F. Linke (Van Nostrand). Reviewed by Henry Feuer.

ASSOCIATION AFFAIRS

SOCIETY AND SECTION HEADQUARTERS IN BERKELEY

IN the advertising portion of this issue is a two-page spread on (i) when advance copies of the 1954 General Program-Directory will be available; and (ii) sleeping accommodations at this year's Berkeley meeting of the Association. The first has a coupon usable both by advance registrants and those who are not planning to attend but would like this book of some 352 pages primarily for its directory content.

The other page announces an unusual variety of sleeping facilities and has an accompanying room reservation coupon with two added questions (pertinent this year) and a request for a small hotel room deposit (customary in California).

With the initial appearance of these two pages, to assist in choosing accommodations, it has been customary to announce the hotels that will be the headquarters of the AAAS, of the sections, and of the participating societies. At Berkeley, however, because the University dormitories will house portions of the memberships of most of the societies, and also because of the size of hotels, it would have been inexpedient to attempt any formal assignment of headquarters hotels for the societies or groups of related sciences. Societies and sections, of course, will have their own session rooms, assigned for maximum convenience to similar programs; societies that wish them will have headquarters *rooms* on or off campus; finally, groups of society members who wish to room close together may do so by booking reservations accordingly and applying early. By use of the Visible Directory of Registrants in the Gymnasium for Men, the adjacent bulletin board and telephone, it will be possible to locate all registrants quickly and to leave messages.

Although none of the hotels is large enough to serve exclusively as the headquarters, for example, of the statisticians, physicists, astronomers, biologists, psychologists, the medical groups, or the science teachers, the housing accommodations are ample in total quantity and variety. There are attractive twin-bedded dormitory rooms with maid service—primarily for students, younger faculty members, and others not on expense accounts—at $2 each person the first night, $1 per night thereafter; rooms without private bath at International House for $2.50, and at the hotels for $2 to $3; and moderately priced rooms with bath in excellent hotels and motels. The top price in suites is $20 per day for rooms overlooking the Golden Gate—not particularly expensive if occupied by four persons. The dormitories will serve breakfast "in"; the hotels serve all meals; and most motels serve no meals.

The Hotel Shattuck will be AAAS headquarters.

Coupon for Housing Reservations

Some further comments should perhaps be ma

1) *All* housing will be cleared through the AA Housing Bureau, operated by the efficient Conventi Bureau.

2) Since all rooms are assigned in order of recei the date of application is important.

3) In general, single rooms at single rates are rel tively scarce in any hotel in any city. When the supp of these is exhausted, only double rooms can be offer for single occupancy—at higher (although not double rates. Thus, it conserves rooms, saves money, and more sociable when two or more persons share a lar room with individual beds. It is hoped many will d this. One person may book a whole block of room provided that he advances the deposits for all person

4) The deposit of $5 per person or $10 per hotel motel room—which does *not* apply to dormitory room —is customary in California. It is refundable if the a commodation is cancelled more than 10 days before th meeting—and usually later, if the room can be assigne to someone else—and, for those who stay only one nigh any excess of deposit is refunded.

5) The space in which to name one's society or sec tional interest is important. Within the choices and pric range indicated, *members of the same society or sectio will be assigned nearby rooms.*

6) Those who drive to the meeting should say so The campus of the University of California at Berkele is compact, so that the dormitories, the Hotels Duran and Shattuck, and other accommodations are all within moderate walking distance of the center of the meet ing—the Gymnasium for Men, the buildings housing th sessions, the University cafeterias, and several off-cam pus restaurants. But there are other comfortable hotel and motels within the city limits for which a car i needed. Those who will have an automobile at th meeting can be assigned to these motels or hotels. There will be parking facilities on the campus for those attend ing the meeting.

Headquarters Rooms

Statisticians, 288 Dwinelle; Physicists, 375 LeConte Herpetologists League, 3598 Life Sciences Building; Western Society of Naturalists, 2507 Life Sciences Build ing; Society of Systematic Zoology, Stephens Memorial Room. Others will be announced later.

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SLEEPING ACCOMMODATIONS AT 121st AAAS MEETING

Berkeley, California, December 26-31, 1954

The hotel, motel, and dormitory sleeping accommodations—their rates and the application coupon below—are for your convenience in making room reservations in Berkeley. Please send your application *directly* to the AAAS Housing Bureau and thereby avoid delay and confusion. The experienced Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less. **Single rooms may become scarce; double rooms for single occupancy cost more; if possible, share a twin-bedded room with a colleague—and also save.** Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival and also probable date of departure.

HOTELS	SINGLE	DOUBLE	TWIN	SUITE
Claremont	5.00–11.00	8.00–13.00	8.00–13.00	14.00–20.00
Durant	4.00– 7.00	6.00– 9.00	6.50–10.00	10.00–16.00
Shattuck	5.00–10.00	7.00–10.00	7.50–10.00	10.00–18.00
Other hotels	3.00– 5.00	3.50– 5.00	4.00– 6.50	7.00–10.00

(Note: Most hotels have singles without private bath at $2.00–$3.50 per night)

MOTELS				FAMILY ROOMS
Berkeley Plaza	5.00	6.00	7.00	8.50–12.00
California	4.00– 4.50	4.50– 5.00	5.50	6.00– 7.00
Golden Bear	4.50– 5.00	5.00– 7.00	6.00– 8.00	7.50–10.00
Other motels	4.00– 5.00	4.00– 6.00	5.50– 8.50	6.00–12.00

Dormitory Accommodations: NOTE: The 766 units in the University of California dormitories are **primarily for students, younger faculty members, and those not on expense accounts.** Occupancy, two persons per room; rate, $2.00 the first night, $1.00 per night thereafter, per person.

International House: Singles only, *without private bath*, $2.50 per night.

For a discussion of the headquarters of the participating societies and sections, please see Association Affairs, *Science*, July 23, or *The Scientific Monthly*, August.

THIS IS YOUR HOUSING RESERVATION COUPON

AAAS Housing Bureau
2223 Fulton Street
Berkeley 4, California

Date of Application .....

Please reserve the following accommodations for the 121st Meeting of the AAAS in Berkeley, Dec. 26–31, 1954:

First Choice ..... **Second Choice** ..... **Third Choice** .....
(State name of hotel, motel, or other)

..... Single Room — Desired Rate ..... — Maximum Rate .....
..... Double-bedded Room — Desired Rate ..... — Maximum Rate .....
..... Twin-bedded Room — Desired Rate ..... — Maximum Rate .....
..... Suite — Desired Rate ..... — Maximum Rate .....
..... Dormitory Unit(s)—two persons per room at $2.00 each first night, $1.00 per night thereafter.

HOTEL AND MOTEL ROOM DEPOSIT

$5.00 per reservation or $10.00 per room (*refunded if cancelled before Dec. 17*)

Make checks payable to "AAAS Housing Bureau."

The name and address of each person, including yourself, must be listed. Attach list if this space is insufficient.

.....

DATE OF ARRIVAL ..... DEPARTURE DATE .....
(These must be indicated—add approximate hour, a.m. or p.m.)

NAME .....
(Individual requesting reservation) (please print or type)

ADDRESS .....
(Street) (City and Zone) (State)

My society (or sectional interest) is: .....

I (will) (will not) have an automobile at the Meeting.

Mail this now to the Housing Bureau (address above). *Enclose hotel or motel room deposit. Make checks payable to AAAS HOUSING BUREAU.* **Rooms will be assigned and confirmed in order of receipt of reservation.**

GET YOUR ADVANCE COPY

of the General Program-Directory of the Berkeley Meeting of the AAAS

By first class mail – early in December

The General Program-Directory of the 121st Meeting of the AAAS on the campus of the University of California, Berkeley, Dec. 26–31, 1954, will be available to anyone, at cost, within the first week in December—whether he can attend the Meeting or not. You will want the General Program-Directory for your reference shelf.

Program content

1. The three-part General Symposium: "Science and Society."
2. Programs of the 18 AAAS sections (symposia and contributed papers).
3. Programs of the more than 70 participating societies.
4. The Special Sessions: AAAS, Academy Conference, Third Berkeley Symposium on Mathematical Statistics and Probability, Conference on Scientific Editorial Problems, National Geographic Society, Pacific Science Board, Phi Beta Kappa, Phi Kappa Phi, RESA, Sigma Xi.
5. Details of the Gymnasium for Men—center of the Meeting—and campus.
6. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
7. Exhibitors in the 1954 Annual Exposition of Science and Industry and descriptions of their exhibits.

Directory content

1. AAAS officers, staff, committees for 1954.
2. Complete roll of AAAS presidents and their fields.
3. The 260 affiliated organizations.
4. Historical sketch and organization of the Association; the Constitution and Bylaws.
5. Publications of the Association.
6. AAAS Awards and Grants—including all past winners.
7. Membership figures by sections.
8. Section committees (Council members) in detail.
9. Local committees.
10. Future Meetings of the AAAS—through 1958.

Advance Registration

Advance registration has these decided advantages: 1) You avoid delay at the Registration Center upon arrival; 2) You receive the General Program-Directory in ample time to decide, unhurriedly, which events and sessions you particularly wish to attend; 3) Your name is posted in the Visible Directory as the Meeting opens.

The following coupon may be used both by advance registrants and by those who wish only the advance copy of the General Program-Directory.

——— THIS IS YOUR COUPON FOR AN ADVANCE COPY OF THE GENERAL PROGRAM-DIRECTORY ———

1a. ☐ Enclosed is $2.50 for my advance Registration Fee which brings me the Program-Directory, Convention Badge, and all privileges of the Meeting.

1b. ☐ Enclosed is $1.50 for only the Program-Directory. (It is understood that, if I should attend the Meeting later, the Badge—which is necessary for all privileges of the Meeting—will be secured for $1.00 more.)
(Check one)

2. FULL NAME (Dr., Miss, etc.) .....
(Please print or typewrite) (Last) (First) (Initial)

3. ACADEMIC, PROFESSIONAL, OR BUSINESS CONNECTION .....

4. OFFICE OR HOME ADDRESS .....
(For receipt of Program-Directory)

5. YOUR FIELD OF INTEREST .....

6. CONVENTION ADDRESS .....
(May be added later, after arrival)

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SCIENTIFIC AND ENGINEERING STAFF

Culver City, Los Angeles County, California

Assurance is required that relocation of the applicant will not cause the disruption of an urgent military project.

Meetings

September, cont. from pg. iv

13–20. International Soc. of the History of Medicine, 14th, Rome and Salerno, Italy. (M. Galeazzi, Città Universitaria, Rome.)

13–25. International Instrument Cong. and Exposition, 1st, Philadelphia, Pa. (R. Rimbach, 921 Ridge Ave., Pittsburgh 12, Pa.)

14–29. International Union of Geodesy and Geophysics, Rome, Italy. (W. E. Smith, 1530 P St., NW, Washington 5, D.C.)

15. International Cong. of Industrial Chemistry, 27th, Brussels, Belgium. (Mr. Guilmot, 32 Rue Joseph II, Brussels.)

15–17. American Assoc. of Clinical Chemists, 6th annual, New York City. (M. M. Friedman, Lebanon Hospital, New York 57.)

15–18. International Cong. of Internal Medicine, 3rd, Stockholm, Sweden. (A. Kristenson, Karolinska Sjukhuset, Stockholm 60.)

17–18. Calorimetry Conf., 9th annual, Schenectady, N.Y. (W. De Sorbo, GE Research Laboratories, Schenectady.)

21–24. American Roentgen Ray Soc., Washington, D.C. (B. R. Young, Germantown Hospital, Philadelphia 44, Pa.)

22–24. Conf. on the Protection of Plants in Hot Climates, Marseilles, France. (P. Bonnet, Palais de la Bourse, Marseilles.)

22–24. Mississippi Valley Medical Soc., 18th annual, Chicago, Ill. (H. Swanberg, 209–224 W. C. U. Bldg., Quincy, Ill.)

22–28. International Symposium on High-Speed Photography and Kinematography, 2nd, Paris, France. (P. Naslin, Laboratoire Central de l'Armement, Fort de Montrouge, Arcueil, France.)

23–28. European Cong. on Clinical Chemistry, 1st, Amsterdam, Netherlands. (Ir. O. Meulemans, Racinelaan 17, Utrecht, Netherlands.)

24. American Medical Writers Assoc., 11th annual, Chicago, Ill. (H. Swanberg, Drawer 110, Quincy, Ill.)

24–25. International Symposium on Problems in Physiology and Pathology of the Eye, Iowa City, Iowa. (F. C. Blodi, Dept. of Ophthalmology, State Univ. of Iowa, Iowa City.)

26. Cong. of International Soc. of Medical Hydrology, Vichy and Paris, France. (G. Ammirandoli, Via Della Torretta 11, Montecatini Terme, Italy.)

26–2. International Union Against Tuberculosis, 13th, Madrid, Spain. (J. Aliz, Calle Francisco Silvela 20, Madrid.)

26–2. World Medical Assoc., 8th general assembly, Rome, Italy. (L. H. Bauer, 345, E. 46th St., New York 17.)

27–2. International Conf. on Engineering Education, 2nd, Switzerland, (L. A. Rose, Univ. of Illinois, Urbana.)

27–2. Symposium on Macromolecular Chemistry, Turin and Milan, Italy. (A. Nasini, Corso Massimo d'Azeglio 48, Turin.)

28. International Committee of Weights and Measures, and Conf. on Weights and Measures, Sevrès, France. (Sec., ICWM, Pavillon de Breteuil, Sevrès.)

New Books Received

Trees and Shrubs of the Southwestern Deserts. ed. 2. Lyman Benson and Robert A. Darrow. Univ. of Arizona Press, Tucson; Univ. of New Mexico Press, Albuquerque, 1954. x + 437 pp. Illus. + plates. $8.50.

The Psychology of the Criminal Act and Punishment. Gregory Zilboorg. Harcourt, Brace, New York, 1954. xi + 141 pp. $3.50.

Physiology in Diseases of the Heart and Lungs. Rev. ed. M. D. Altschule. Harvard Univ. Press, Cambridge, 1954. xv + 554 pp. $7.50.

Science, Medicine and History. Essays on the evolution of scientific thought and medical practice written in honour of Charles Singer. E. Ashworth Underwood, Ed. Oxford Univ. Press, London–New York, 1953. Vol. I, xxxii + 563 pp.; Vol. II, viii + 646 pp. Illus. + plates. $45 the set.

Matthews' Textile Fibers. Their physical, microscopic, and chemical properties. ed. 6. Herbert R. Mauersberger, Ed. Wiley, New York; Chapman & Hall, London, 1954. x + 1283 pp. Illus. $16.50.

The Behavior and Social Life of Honeybees. C. R. Ribbands. Bee Res. Assoc., London; Hale, Hapeville, Ga., 1953. 352 pp. Illus. + plates. $4.50.

The Western End of Lake Erie and its Ecology. Thomas H. Langlois. J. W. Edwards, Ann Arbor, Mich., 1954. xx + 479 pp. Illus. $10.

Electronics. A textbook for students in science and engineering. Thomas Benjamin Brown. Wiley, New York; Chapman & Hall, London, 1954. xi + 545 pp. Illus. $7.50.

The Collected Papers of Stephen P. Timoshenko (In German, French, and English). McGraw-Hill, New York–London, 1953. xxv + 642 pp. Illus. $15.

Optical Workshop Principles. Eng. ed. 2. Trans. of *Le Travail des Verres d'Optique de Précision*. Charles Dévé. Trans. by Thomas L. Tippell. Hilger & Watts, London, 1954. xxiv + 436 pp. Illus. + plates. 4s.

The Biochemistry of Genetics. J. B. S. Haldane. Macmillan, New York, 1954. 144 pp. $2.75.

Cohort Fertility. Native white women in the U.S. Pascal K. Whelpton. Princeton Univ. Press, Princeton, N. J., 1954. xxv + 492 pp. Illus. $6.

Characteristics and Applications of Resistance Strain Gages. Proc. of NBS Symposium held Nov. 8–9, 1951. National Bur. of Standards, Washington, D. C., 1954 (Order from Supt. of Documents, GPO, Washington 25, D. C.). iv + 140 pp. Illus. $1.50.

Sea-Birds. An introduction to the natural history of the sea-birds of the North Atlantic. James Fisher and R. M. Lockley. Houghton, Mifflin, Boston, 1954. xvi + 320 pp. Illus. + plates. $6.

Dynamics of Growth Processes. L. M. Kozloff *et al.* Edgar J. Boell, Ed. Princeton Univ. Press, Princeton, N. J., 1954. vii + 304 pp. Illus. + plates. $7.50.

Fundamentals of the Working of Metals. G. Sachs. Interscience, New York; Pergamon Press, London, 1954. vii + 158 pp. Illus. + plates. $4.75.

Energy Transfer in Hot Gases. Proc. of NBS Symposium held Sept. 17–18, 1951. National Bur. of Standards, Washington, D. C., 1954 (Order from Supt. of Documents, GPO, Washington 25, D. C.). iv + 126 pp. Illus. $1.50.

General Chemistry. Edwin C. Markham and Sherman E. Smith. Houghton, Mifflin, Boston, 1954. x + 613 pp. Illus. $6.

After High School—What? Ralph F. Berdie; with chapters by Wilber L. Layton and Ben Willerman. Univ. of Minnesota Press, Minneapolis, 1954. xii + 240 pp. $4.25.

Tropical Meteorology. Herbert Riehl. McGraw-Hill, New York–London, 1954. x + 392 pp. Illus. $8.50.

L'Hygiène de la Vue. Ernest Baumgardt. Presses Universitaires de France, Paris, 1954. 125 pp. Illus.

Airplane Structures. Vol. I. ed. 4. Alfred S. Niles and Joseph S. Newell. Wiley, New York; Chapman & Hall, London, 1954. xv + 607 pp. Illus. $7.75.

Synthetische Artbildung. Vols. I and II. Grundlinien einer exakten Biologie. Heribert Nilsson. Verlag CWK Gleerup, Lund, Sweden, 1953. 1303 pp. Illus. Cloth, 250 krona; paper, 225 krona.

Modern Chemical Processes. Vol. III. A series of articles describing chemical manufacturing plants. Eds. of *Industrial and Engineering Chemistry*. Reinhold, New York, 1954. v + 276 pp. Illus. $5.

Name Reactions in Organic Chemistry. Alexander R. Surrey. Academic Press, New York, 1954. viii + 192 pp. $4.

Theory of Functions of a Complex Variable. Vol. I C. Carathéodory. Trans. by F. Steinhardt. Chelsea, New York, 1954. xii + 301 pp. Illus. $4.95.

Dvorine Pseudo-Isochromatic Plates. ed. 2. Israel Dvorine. Israel Dvorine, 2328 Eutaw Pl., Baltimore 7, Md. $12.

Silage Fermentation. A. J. G. Barnett. Academic Press, New York; Butterworths, London, 1954. x + 208 pp. Illus. $5.

The Statistical Approach to X-ray Structure Analysis. Vladimir Vand and Ray Pepinsky. Pennsylvania State Univ., State College, 1953. xvi + 98 pp. Illus. Paper, $1.50.

The Magic of Electronics. Edward J. Bukstein. Frederick Ungar Pub., New York, 1954. 256 pp. Illus. $3.95.

A Short History of Technology. Harold G. Bowen and Charles F. Kettering. Thomas Alva Edison Foundation, West Orange, N. J., 1954. 118 pp. Illus.

Nine Tales of Space and Time. Raymond J. Healy, Ed. Henry Holt, New York, 1954. x + 307 pp. $3.50.

Recent Progress in Hormone Research. Vol. IX. Proc. of the Laurentian Hormone Conf. Gregory Pincus, Ed. Academic Press, New York, 1954. 467 pp. Illus. $9.50.

Physical and Chemical Aspects of Basic Mechanism in Radiobiology. John L. Magee, Martin D. Kamen, and Robert L. Platzman, Eds. National Res. Council, Washington, D. C., 1953. vii + 145 pp. Illus. $1.

Introduction to College Physics. Rogers D. Rusk. Appleton-Century-Crofts, New York, 1954. xxii + 816 pp. Illus. $6.50.

General Chemistry. A topical introduction. Eugene G. Rochow and M. Kent Wilson. Wiley, New York; Chapman & Hall, London, 1954. xiii + 602 pp. Illus. $6.

Peripheral Circulation in Man. A Ciba Foundation Symposium. G. E. W. Wolstenholme and Jessie S. Freeman, Eds. Little, Brown, Boston, 1954. xi + 219 pp. Illus. + plates. $6.

Relaxation Methods. D. N. de G. Allen. McGraw-Hill, New York–London, 1954. ix + 257 pp. Illus. $7.50.

Neuere Probleme der Abstammungslehre. Die trans-

spezifische Evolution. ed. 2. Bernhard Rensch. Ferdinanc Enke, Stuttgart, Ger., 1954. 436 pp. Illus. DM 49.20.

How Strong Is Russia? A geographic appraisal. George B. Cressey. Syracuse Univ. Press, Syracuse, N. Y., 1954. ix + 146 pp. Illus. $3.

4000 Years under the Sea. The story of marine archaeology. Philippe Diolé. Trans. by Gerard Hopkins. Messner, New York, 1954. xiv + 237 pp. Illus. $4.50.

An International Biliography on Atomic Energy. Vol. 2: Scientific Aspects. Supp. No. 2. UN, New York, 1953. (U. S. Distr.: Columbia Univ. Press, New York.) vii + 320 pp. $3.50.

Atomic Energy: A Survey. J. Rotblat, Ed. Taylor & Francis, London, 1954 (For the Atomic Scientists' Assoc.). viii + 72 pp. Illus. + plates. Cloth, 6s 6d; paper, 4s 6d.

Know Your Reader. The scientific approach to readability. George R. Klare and Byron Buck. Hermitage House, New York, 1954. 192 pp. $2.95.

Graphics in Engineering and Science. A. S. Levens. Wiley, New York; Chapman & Hall, London, 1954. viii + 696 pp. Illus. $7.

Wine as Food and Medicine. Salvatore P. Lucia. Blakiston, New York, 1954. 149 pp. $3.

General Pscyhology. ed. 4. Douglas H. Fryer, Edwin R. Henry, and Charles P. Sparks. Barnes & Noble, New York, 1954. xix + 300 pp. Illus. Paper, $1.50.

American Seashells. R. Tucker Abbott. Van Nostrand, New York, 1954. xiv + 541 pp. Illus. + plates. $12.50.

Geschichte der Mathematik. J. E. Hofmann. Walter de Gruyter, Berlin, 1953. 200 pp. DM 2.40.

The Cultivation of Animal and Plant Cells. Philip R. White. Ronald Press, New York, 1954. xi + 239 pp. Illus. $6.

Physical Geology. L. Don Leet and Sheldon Judson. Prentice-Hall, New York, 1954. ix + 466 pp. Illus. $6.75.

A Laboratory Manual of Vertebrate Embryology. ed. 3. F. B. Adamstone and Waldo Shumway. Wiley, New York, 1954. vi + 98 pp. Illus. $2.50.

Electronics. An electrical engineering approach. George F. Corcoran and Henry W. Price. Wiley, New York; Chapman & Hall, London, 1954. x + 459 pp. Illus. $7.

Introduction to Vertebrate Embryology. ed. 5. Waldo Shumway and F. B. Adamstone. Wiley, New York; Chapman & Hall, London, 1954. x + 389 pp. Illus. $6.

Engineers' Dreams. Willy Ley. Viking Press, New York, 1954. 239 pp. Illus. $3.50.

Physics and Applications of Secondary Electron Emission. H. Bruining. McGraw-Hill, New York; Pergamon Press, London, 1954. xii + 178 pp. Illus. $5.

Vector and Tensor Analysis. G. E. Hay. Dover, New York, 1953. viii + 193 pp. Illus. Cloth, $2.75; paper, $1.50.

The Origins of Psycho-analysis. Letters to Wilhelm Fliess, drafts and notes: 1887–1902. Sigmund Freud. Marie Bonaparte, Ann Freud, and Ernst Kris, Eds. Trans. by Eric Mosbacher and James Strachey. Basic Books, New York, 1954. xi + 486 pp. $6.75.

The Challenge of Our Times. Contemporary trends in science and human affairs as seen by 20 professors at the Univ. of Wisconsin. Farrington Daniels and Thomas M. Smith, Eds. Burgess, Minneapolis, 1953. viii + 364 pp. $3.50.

The Freshwater Fishes. Vol. I. Eng. ed. 1. Key to game and commercial fishes of the Prov. of Quebec. Vianney Legendre. Quebec Biological Bur., Montreal, 195[illegible] 180 pp. ***Les Poissons d'Eau Douce,*** Vol. 1. Fr. ed.

Petrography. An introduction to the study of rocks [illegible] thin sections. Howel Williams, Francis J. Turner, a[illegible] Charles M. Gilbert. W. H. Freeman, San Francis[illegible] 1954. x + 406 pp. Illus. $6.50.

Proceedings of the Ankara Symposium on Arid Zo[illegible] Hydrology. UNESCO, Paris, 1953. 268 pp. Illus.

Traité de Pisciculture. ed. 2. Marcel Huet, Editions L[illegible] Vie Rustique, Brussels, 1953. xii + 371 pp. Illus.

Country Doctor. Cornelius Wilson Larison, 1837–191[illegible] Harry B. Weiss. New Jersey Agric. Soc., Trenton, 195[illegible] 235 pp. Illus. Paper, $2.50.

The Vitamins: Chemistry, Physiology, Pathology Vol. I. W. H. Sebrell, Jr. and Robert S. Harris, Ed[illegible] Academic Press, New York, 1954. xiii + 676 pp. Illus. $16.50.

Essays in Experimental Logic. John Dewey. Dover, New York, 1953 (Reprint of 1903 ed.). 444 pp. Cloth, $3.50; paper, $1.75.

Transactions of the Symposium on Fluid Mechanics and Computing. Sponsored by the American Mathematical Soc. and Office of Ordnance Res., U. S. Army. Garrett Birkhoff, K. O. Friedrichs, and T. E. Sterne, Eds. Interscience, New York–London, 1954. 243 pp. Illus. $5.

The Fundamentals of College Chemistry. ed. 2. G. Brooks King and William E. Caldwell. American Book, New York, 1954. viii + 589 pp. Illus. $4.50.

A First Year of College Mathematics. ed. 2. Raymond W. Brink. Appleton-Century-Crofts, New York, 1954. xvi + 725 pp. Illus. $5.

Essays in Sociological Theory. Rev. ed. Talcott Parsons. Free Press, Glencoe, Ill., 1954. 459 pp. $6.

Thomas Young, Natural Philosopher: 1773–1829. The late Alexander Wood; completed by Frank Oldham. Cambridge Univ. Press, New York, 1954. xx + 355 pp. Illus. + plates. $6.

Concerning the Nature of Things. Sir William Bragg. Dover, New York, 1954 (Reprint of 1948 ed.). xi + 231 pp. Illus. + plates. Cloth, $2.75; paper, $1.25.

The Social Function of Art. Radhakamal Mukerjee. Philosophical Library, New York, 1954. xxii + 280 pp. + index + plates. $10.

Crystal Data. Classification of substances by space groups and their identification from cell dimensions. Geological Soc. of America Mem. 60. J. D. H. Donnay and Werner Nowacki. Geological Society, New York, 1954. ix + 719 pp.

Lubrication of Indutsrial and Marine Machinery. ed. 2. The late William Gordon Forbes; rev. by C. L. Pope and W. T. Everitt. Wiley, New York; Chapman & Hall, London, 1954. viii + 351 pp. Illus. $6.50.

Copper. The science and technology of the metal, its alloys and compounds. Allison Butts, Ed. ACS Monogr. Ser., No. 122, William A. Hamor, Ed. Reinhold, New York, 1954. xii + 936 pp. Illus. $20.

Annuario Generale. Accademia Nazionale Dei XL, Rome, 1953. 536 pp. + index. + plates.

Compounds with Condensed Thiophene Rings. Howard B. Hartough and S. L. Meisel. Part of *The Chemistry of Heterocyclic Compounds* Ser., Arnold Weissberger, Ed. Interscience, New York–London, 1954. xv + 515 pp. Illus. Single copy, $16.50; subscription, $15.

Foundations of Potential Theory. Oliver Dimon Kellogg. Dover, New York, 1953 (Reprint of 1929 ed.). ix + 384 pp. Illus. Cloth, $3.95; paper, $1.90.